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J. C. Branner

FINAL REPORT

ON THE

GEOLOGY OF MASSACHUSETTS:

VOL. I.

CONTAINING

I. ECONOMICAL GEOLOGY.

II. SCENOGRAPHICAL GEOLOGY.

BY EDWARD HITCHCOCK, LL. D.

PROFESSOR OF CHEMISTRY AND NATURAL HISTORY IN AMHERST COLLEGE: GEOLOGIST TO THE STATE OF MASSACHUSETTS, ETC.

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1841.

To His Excellency Edward Everett,
Governor of Massachusetts:

Sir,

I am happy to be able at length to present you with my final Report on the Geology of Massachusetts. I have divided it into four Parts:

1. ECONOMICAL GEOLOGY:
2. SCENOGRAPHICAL GEOLOGY:
3. SCIENTIFIC GEOLOGY:
4. ELEMENTARY GEOLOGY.

The *Economical Geology* contains a description of all the minerals and rocks in the State hitherto discovered, that have been applied to useful purposes. To this part of the subject I have devoted more attention since my re-appointment as State Geologist, than to any other. The difficult yet important subject of soils; their chemical composition, geological character, and means of improvement, were scarcely alluded to in my former general report; but in the present one, it occupies a conspicuous place. By the liberal assistance of a distinguished chemical friend, I have brought forward on this subject many new views, which I trust will prove valuable. In applying these views, numerous analyses have been requisite. I have performed many others, also, upon other substances, to ascertain their value: so that the whole number which I have given, amounts to about 400. In fact, my former reports exhibit but a meagre account of our economical geology, compared with the present; however imperfect even this may be.

The *Scenographical Geology* embraces a description of the most remarkable natural scenery of the State, accompanied by drawings of the most interesting spots. These drawings I have succeeded in obtaining through the liberality of several artists, who have gratuitously accompanied me in my tours; and though they should be engraved in plain style, they may aid in calling the attention of our citizens to striking features in our scenery, that are now generally passed unnoticed. This is the chief object of this part of my Report: and if I succeed in it, I shall feel as if an important point were gained.

The *Scientific Geology* considers the bearings of the subject upon the principles of the science, without direct reference to practical utility: although the theoretical principles of this science have an important relation to practical utility. On this part of the subject a great number of new and curious facts have come to my knowledge since the publication of my former Reports. I have spent a great deal of time also, in tracing out more accurately the boundaries of the different rock formations upon the accompanying corrected geological map. I have also added to the State Collection of rocks, minerals, and soils, 1303 specimens; so that the whole number now amounts to 2857.

Under *Elementary Geology*, I have given a condensed view of the terms, principles and theories of the science of geology in general. I have done this in the hope of aiding those persons who may wish to read this Report, who have not the leisure or the means of consulting the larger works that have been published on the subject. My chief fear is, that I have been obliged, for want of room, to condense it so much as to make it obscure.

I cannot close this protracted labor, without expressing my obligations to your Excellency, and to your predecessors in office since the commencement of the Geological Survey, for the

kind and liberal manner with which my efforts have been encouraged and my deficiences over looked; for the judicious counsels and instructions which I have received; and for the personal favor and attention with which I have been treated.

Nor would I forget my indebtedness to the other branches of the Government for the liberal patronage and support which they have bestowed upon this enterprise.

Let me here, also, testify to the universal disposition which I have found manifested in every part of the Commonwealth, to forward the objects of the survey. For ten years,—I might in truth say twenty,—I have spent a principal portion of my time in wandering over the State. I have climbed all her mountains. I have penetrated her most sequestered valleys and glens. In short, I have traveled within her boundaries not less than 10.000 miles; not with rail road speed, but rather with a geological, which is nearly synonomous with a pedestrian pace: yet have I everywhere met with a hospitality that has supplied all my wants, and with intelligence enough to understand and appreciate, and a disposition to forward, the objects of my commission. These circumstances have given a deep interest to my geological excursions, and make the retrospect of them among the happiest recollections of my life; while they have greatly exalted my opinion of the kindness, intelligence, and happy condition of our population, and increased my attachment to my native State.

It may not be irrelavent to state, that since Massachusetts begun this geological exploration, no less than eighteen other States of the Union have commenced, and are now actively prosecuting, or have completed, similar surveys: while the Government of the United States, as well as some European Governments, especially that of Great Britain, have followed the same example.

Finally, and above all, I desire to acknowledge and feel my supreme obligations to that kind Providence, which has followed me in all my wanderings, defended me from all serious accident and danger, and enabled me to bring to a conclusion one of the most laborious enterprises of my life. To Him, therefore, I desire to consecrate the fruits of this labor, and the little remnant of strength and of life that remain to me; in the humble hope that they may be accepted; and that upon a retrospect of my days, I may feel that I have not lived entirely in vain.

Respectfully submitted,

Amherst College, Dec. 1, 1839. EDWARD HITCHCOCK.

Note.

It may be proper to say, that the great length of time which has been necessarily consumed in printing the following Report, has enabled me to discover many facts since it was first presented to the Government. These I have not hesitated to incorporate into the work, as the reader will see, without consulting the Government. This statement may, indeed, show that the work is even yet imperfect. But this fact I have no disposition to conceal. If I can flatter myself that I have done something towards developing our subterranean resources, and made the work easier for those who succeed me, I ought not to lay claim to more. E. H.

Amherst College, April 1, 1841.

HISTORY OF THE SURVEY.

On the third of March 1830, the Legislature of Massachusetts passed a Resolve, authorizing and requesting the Governor with the advice of the Council, 'to appoint a Surveyor well skilled in astronomy and in the art of surveying upon trigonometrical principles,—to make a general survey of the Commonwealth, and from such astronomical observations and calculations as may be made, to project an accurate skeleton plan of the State, which shall exhibit the external lines thereof and the most prominent objects within those lines and their locations.'

In Governor Lincoln's Message to the Legislature May 29th, 1830, we find the following recommendation.

'I beg leave to suggest to your consideration the utility of connecting with the Geographical Surveys, an examination of the geological features of the State, with a view to the exhibition of them on the map. Much knowledge of the natural history of the country would thus be gained, and especially the presence of valuable ores, with the localities and extent of quarries, and of coal and lime formations, objects of enquiry so essential to internal improvements, and the advancement of domestic prosperity, would be discovered, and the possession and advantages of them given to the public. I am assured that much has already been gratuitously done, by some eminent professors in our colleges, towards the accomplishment of such a work, and that, at a little expense, it might be completed, and the fruits of their generous labors thus far, be secured to the State. This, however, will require the interposition of your authority in increasing the present appropriation, and permitting an application of it, so far as may be necessary, in the exercise of a sound discretion to the end proposed.'

In conformity with these suggestions, the Legislature, on the 5th of June, 1830, '*Resolved*, That his Excellency the Governor, by and with the advice of the Council, be, and he is hereby authorized to appoint some suitable person, to make a geological examination of the Commonwealth, in connection with the general survey, in order that the same may be inserted on the map which may be published, &c.

On the 26th of June 1830, Governor Lincoln issued a Commission to the author of the following Report, directing him 'to make the geological examination of this Commonwealth, in the manner contemplated by said Resolve, performing such duties relating thereto, as are or may be enjoined upon you; and obeying such instructions as, from time to time, you may receive from the proper authority.'

February 2d. 1831, the Legislature still further authorized His Excellency the Governor, 'to direct the person who is appointed to make a Geological Survey of the Commonwealth, to cause to be annexed to his report on that subject, a list of the native Mineralogical, Botanical and Zoological productions of the Commonwealth, so far as it may be practicable to ascertain the same within the limits of the appropriation already made for this Survey.

A Report on the Economical Geology of the State, with a Geological Map, having been presented to the Government in the beginning of the year 1832, it was ordered to be printed: and on the 24th of March 1832, the Legislature '*Resolved*, that the 600 copies of the first part of the Report on the Geological Survey of the Commonwealth, provided in pursuance of an arrangement made by his Excellency the Governor with the advice of Council, for the use of Government, be delivered to the Secretary of the Commonwealth, and by him be distributed, as follows, viz.

'Four copies to the Governor; two copies to the Lieutenant Governor; One copy to each member of the Council; One copy to each member of the Senate and House of Representa-

tives; five copies to be deposited in the Library of the State: and that the remaining copies be distributed as His Excellency the Governor may direct.'

In the early part of 1833, a full Report was presented, and the Legislature on the 25th of February adopted the following very liberal Resolves:

'*Resolved*, that His Excellency the Governor, be, and hereby is authorized to cause twelve hundred copies of the Report on the Geological Survey of the Commonwealth; including that part of the Report already made, as well as the part hereafter to be made, with the drawings which shall accompany said Report, to be published in such way and manner as he shall deem proper and expedient; and he is authorized with the advice and consent of Council, to draw his warrant upon the Treasurer of the Commonwealth for such sum, or sums, as may be necessary to carry this resolve into full effect.'

'*Resolved*, that the said twelve hundred copies, when published, shall be delivered to the Secretary of the Commonwealth, to be distributed in the following manner, viz: twelve copies to the Governor; six copies to the Lieut Governor; one copy to each member of the Council, Senate and House of Representatives; one copy each to the Secretary, Treasurer, and to each of the Clerks and Chaplains of the two Houses; one copy to each town in the Commonwealth; five copies to be deposited in the Library of the State; two copies each to Harvard, Amherst and Williams Colleges; one copy each to the Theological Seminaries at Andover and Newton; one copy to each incorporated Academy in the Commonwealth; one copy each to the Boston and Salem Atheneums; one copy to the American Academy of Arts and Sciences: one copy to the Antiquarian Society at Worcester; one copy to the Massachusetts Historical Society; one copy to the Boston Society of Nataral History; twenty copies to the Geological Surveyor; and one copy to each person who shall have aided him in preparing the Catalogues appended to the Report; two copies to the Library of the United States; one copy to the Executive of each State in the Union, and the remaining copies to be disposed of in such a manner as His Excellency the Governor shall direct.'

On the 19th of February 1834, the following Resolve was adopted by the Legislature:

'*Resolved*, that his Excellency the Governor with the advice of the Council, be authorized to cause to be printed, under the superintendence of the Geological Surveyor, a new edition of Professor Hitchcock's Report on the Geology of this Commonwealth, and the Atlas accompanying it, with such alterations and additions as may be proposed by the Professor, and approved by the Executive; and that a warrant be drawn on the Treasurer for such sum as may be necessary to defray the expense thereof: provided that the whole expenditure shall not exceed the sum of two dollars and sixty cents for each copy.'

'*Resolved*, that the said five hundred copies, when published, shall be delivered to the Secretary of the Commonwealth, and be distributed in the following manner, viz.

Twelve copies to the Governor; ten copies to the Surveyor; one copy to each of the Chaplains of the Senate and House of Representatives; one copy to each incorporated Lyceum and Atheneum in this Commonwealth; two copies each to the Berkshire Medical Institution, and the Massachusetts Medical College; one copy to each member of the Council, Senate, and House of Representatives, who was not a member of either of those branches of the government for the last year; one copy to each of the permanent Clerks in the office of the Secretary of State, Treasurer, and Adjutant General, two copies to the Pilgrim Society at Plymouth; and the remaining copies to be disposed of in such a manner as the Legislature may direct.'

On the 12th of April 1837, the Governor and Council were authorized and requested to appoint some suitable person or persons to make a further and thorough geological, mineralogical, botanical and zoological survey of this Commonwealth, under his direction, particularly in reference to the discovery of coal, marl, and ores, and an analysis of the various soils of the State, relative to an agricultural benefit.

A Report of 139 pages on the Economical part of the Re-survey was made in the winter of 1838, and printed without any special order. In December 1839 the Final Report was presented, and the Governor was authorized to procure the publication of 1500 copies by a Resolve passed April 9th 1839, which were to be distributed as follows.

Resolved, That the said copies, when published, be delivered to the Secretary of the Commonwealth, to be distributed in the following manner: twelve copies to the Governor; six copies to the Lieut. Governor; one copy to each member of the Council, Senate, and House of Representatives; one copy each to the Secretary, Treasurer, and to each Clerk and Chaplain of the two Houses; one copy to the Secretary and one to each member of the board of Education; twenty copies to the Geological Surveyor, and ten to each Commissioner appointed under the resolve of April 12th, 1837; five copies to be deposited in the library of the State; one copy to each town in the Commonwealth; two copies each, to Harvard, Amherst, and Williams colleges; one copy each to the theological seminaries of Andover and Newton; one copy to each incorporated Atheneum, Lyceum, and Academy, in the Commonwealth; one copy to the American Academy of Arts and Sciences; one copy to the Antiquarian Society at Worcester, and one to the Pilgrim Society at Plymouth; one copy to the Massachusetts Historical Society, and to every other incorporated historical Society in the Commonwealth; one copy to the State Lunatic Hospital at Worcester; one copy to the Boston Society of Natural History; one copy to the Essex County Natural History Society; one copy each to the Massachusetts and Salem Charitable Mechanic Associations; one copy to the library of the East India Marine Society, in Salem; two copies to the library of the United States; one copy to the Executive of each State in the Union; one hundred copies to be placed at the disposal of the Governor, and the remainder to be subject to the further order of the Legislature.

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Errata.

Only the following Errors of much importance have yet been noticed. Many in orthography and punctuation will undoubtedly be found; but it is hardly necessary to notice any here, unless they are such as to mislead the reader.

p. 49, line 20 from top, for 241 and 242, read 185 and 187: make the same correction in lines 25 and 28 from top.

p. 125, in the caption of the composition of crenic acid, transpose *oxygen* and *carbon*.

p. 325, line 17 from top, for *at* read *as*.

p. 358, line 5 from bottom, after *abutments* add, *and piers*.

p. 423, at top, for Plate 55, read, Plate 54.

p. 425, line 14 from top, for Plate 55, read, Plate 54.

p. 807 against No. 2591, for *Wrentham*, read *Mansfield*: and against No. 2592 for the right hand *do*, read *Wrentham*.

POSTSCRIPT.

In sciences pursued with so much zeal and ability as Geology and Chemistry at the present day, the lapse of a year often brings out important discoveries. During the longer period in which this Report has been in press, some developments have been made important enough in my opinion to demand a Postcript. They are inserted at the beginning of the Report, both because of their importance, and because of the well known fact that this is the last part of a work that is printed.

New Work on Organic Chemistry.

Professor Liebig of the University of Giessen, has recently published a work on *Organic Chemistry in its applications to Agriculture and Physiology*, which contains many new views in relation to the nutrition and development of plants. All these views, coming as they do from one of the most distinguished organic chemists living, will be examined by scientific men with great respect, and some of them adopted at once as obvious discoveries and improvements. He seems to have proved that the atmosphere contains ammonia, and justly imputes much to its agency in the growth of plants. Indeed, he makes nitrogen much more important in vegetation than has been supposed. He maintains that the favorable influence of gypsum results from its fixing the ammonia of the atmosphere in the soil by converting it into a sulphate. The important principle suggested and defended by Dr. Dana, and confirmed by all the analyses given in this Report, that phosphates exist naturally in all soils, is also maintained by Liebig, without any knowledge of course that the same view had been taken on this side of the Atlantic. His suggestions respecting the rationale of a rotation of crops, and many other points in practical agriculture, are ingenious and important.

As to the manner in which plants are nourished, Liebig adopts the opinion of Raspail, that their carbon is derived wholly from the imbibition of carbonic acid, either from the atmosphere or the soil. He denies that they absorb geine, or any of its compounds, as nourishment; and he supposes that the geine (humus, or humic acid,) acts only as a means of generating carbonic acid by the changes which it undergoes. It is not my intention to go into any argument on these points in this postscript. But it is a little curious, that Liebig, in attempting to show that there are no means in soils for dissolving more than an infinitessimal quantity of geine, should have overlooked the two most important means of its solution. He supposes that rain water is the only agent in this work. But growing plants have the power of decomposing silicates, and thus of setting free potassa and other bases eminently adapted for the solution of geine. Again, the changes which geine undergoes in the soil produce a great quantity of water, sufficient, according to Nicholson's Journal, to cause an evaporation of 5000 pounds per hour from a well manured acre: quite equal to that resulting from the most copious rains. (*See Webster's Liebig, p.* 398.)

The views of Dr. Dana on these points, I ought perhaps to remark, are those which have most widely prevailed among scientific men in modern times, viz. that plants derive their nourishment partly by absorption from the atmosphere, and partly by taking up soluble matters from the soil. Headmits even, that they may absorb carbonic acid by their roots; nor does he decide upon the exact proportion in which nourishment is derived from these different sources. Indeed, it would not be surprising if it should appear, that plants have such a power of adapting themselves to different circumstances, that they might sometimes sustain themselves exclusively from the atmosphere, and sometimes from the soil: sometimes by carbonic acid alone, and sometimes by geine alone. If such be the case, it might reconcile some of the conflicting experiments and opinions on this subject.

Organic Matters in Soils.

Although chemists have long been agreed that several distinct compounds exist in the organic matter of soils, they are not agreed as to their exact number. According to Dr. C. T. Jackson, Berzelius, the distinguished chemist who first proposed the term geine, in a late edition of his Chemistry has dropped that term, and substituted for it that of humic acid. He has also substituted *humin* for carbonaceous mould. He still employs the terms crenic and apocrenic acid, and extract of humus; and these substances, with humic acid and humin, and occasionally traces of glairin, embrace all yet detected in the organic matter of soils, which he denominates humus. This humus corresponds to the geine of Dr. Dana, when he uses that term agriculturally. He then embraces in it crenic and apocrenic acid, humic acid, and humin; which he regards as forms of geine; divided by him into two classes, the soluble and insoluble. It is in this sense that the term geine is used in Dr. Dana's rules of analysis given in this Report. It is true, when he uses the term chemically, he means the same by it as Berzelius does by humic acid: though as the extract of humus and humin of the same author, do not differ in composition from the humic acid, these also are embraced in geine. Dr. Dana, however, would not have given his views concerning the chemical nature of geine, had he not been requested: for he does not regard this essential in treating the subject agriculturally. In a letter to Mr. Colman, the Agricultural Surveyor, he says, " whether we consider geine as a simple substance, or composed of several others called crenic, apocrenic, puteanic, ulmic acids, glairin, apotheme, extract of humus, or mould, agriculture ever has considered it, and probably ever will consider it one and the same thing, requiring always similar treatment to render it soluble when produced; similar treatment to render it an effectual manure."

According to these views, whose truth is founded not on theory but experience, we can see how analyses of soils may be usefully conducted according to Dr. Dana's rules, even though there be a diversity of opinion among learned men as to the chemical nature of the organic matter of soils, and the mode in which plants are nourished. For whether geine consists of one or twenty substances, and whether it be directly imbibed by plants, or only furnish carbonic acid, the fact still remains equally true, that the fertility of a soil depends in a good degree upon the amount of soluble geine which it contains.

These remarks seemed to me important to prevent a misapprehension of the language and principles of Dr. Dana in this Report.

Distribution of Sea Shells.

In Dr. Gould's Report on the Mollusca of Massachusetts just published, a fact of no small geological interest is given respecting the marine shells found on the opposite sides of Cape Cod. I present it in his own language.

"The distribution of the marine shells is well worthy of notice as a geological fact. Cape Cod, the right arm of the Commonwealth, reaches out into the ocean some fifty or sixty miles. It is no where many miles wide, but this narrow point of land has hitherto proved a barrier to the migrations of many species of *Mollusca*. Several genera and numerous species, which are separated by the intervention of only a few miles of land, are effectually prevented from mingling by the Cape, and do not pass from one side to the other. No specimen of *Cochlodesma*, *Mantacuta*, *Cumingia*, *Corbula*, *Ianthina*, *Tornatella*, *Vermetus*, *Columbella*, *Cerithium*, *Pyrula* or *Ranella*, has as yet been found to the north of Cape Cod; while *Panopea*, *Glycymeris*, *Terebratula*, *Cemoria*, *Trichotropis*, *Rostellaria*, *Cancellaria*, and probably *Cyprina* and *Cardita*, do not seem to have passed to the south of it. Of the 197 marine species, 83 do not pass to the south shore, and 50 are not found on the north shore of the Cape. The remaining 64 take a wider range, and are found on both sides."

Report on the Fossil Footmarks.

In my account of the fossil footmarks in the Connecticut valley, I have quoted the opinion of two distinguished European geologists concerning them. I have now the satisfaction of giving the views of several eminent geologists of our own country on the same point. At a meeting of the Association of American Geologists in Philadelphia, in April 1840, a Committee was appointed "to visit the localities and report their conclusions at the next meeting." At that meeting, held in the same city in April 1841, the following Report was presented.

Report on the Ornithichnites or Footmarks of extinct Birds in the New Red Sandstone of Massachusetts and Connecticut, observed and described by Prof. Hitchcock, of Amherst.

The undersigned, forming the Committee to whom the subject of the origin of the Bird tracks of Professor Hitchcock was assigned, beg leave to present the following brief Report. It may be well previously to state, that the object of the meeting in appointing this Committee was founded solely upon the desire to produce if possible unanimity of opinion, there being a few of the members who dissented from the views published by Professor Hitchcock. In our country the subject, as it undoubtedly ought, had attracted considerable attention. It had been very favorably received and republished in Europe; and from its great importance to Palæozoic Geology, an attempt should be made to settle the question: for were the views of our highly respected member correct, we were made acquainted with the earliest period in which biped animals existed, whose footmarks were analogous to, if not identical with those of the tread of birds: On the contrary, if wrong, we were presented with another class of facts, which show that certain appearances supposed to belong solely to animal life, were held or presented by the vegetable kingdom likewise. We shall now state in a few words, what we suppose are the general facts upon which Prof. Hitchcock's views were founded, and then the facts of those who assumed the opposite opinion. The first and most obvious impression upon the mind on looking at the indentations or marks, is their tri-partite form, resembling the tread or footmarks of those kinds of Birds, which have three toes, the fourth one being rudimental, and are referrible to no other known kind of animal. The tracks or footmarks in several localities are arranged in a determinate order, like those of a bird or fowl, moving in a straight line: the toes or marks in all such cases being alternate; that is, if the right foot be presented on the rock, the left would next follow, and thus right and left in regular succession, sometimes with many repetitions. In other instances the footmarks presented no determinate direction or order, as might naturally be supposed of a bird or any other animal having no particular place or object in view. In all cases where a succession of tracks was observed, there was an uniform correspondence as to size, and considerable regularity as to distance, between the tracks. Whatever deviations were observed, they were not greater than might be supposed to take place in animals possessed of voluntary motion. On some surfaces not unfrequently one or more different kinds of tracks were exposed, belonging, as was reasonably conjectured, to different species and genera of Ornithichnites. That the slaty material of the rock showed that the impressing body possessed force or weight, for frequently the thin layers or laminæ were bent downwards for an inch or more, and that the mud of which the slate was formed was of a highly adhesive or tenacious character. In all cases the footmarks or part impressed, was the fixed part of the rock; the part removed when the lower side was turned upwards, showed the cast or what corresponded with the toes or foot. That no trace of any organic matter could be perceived occupying the cavity or mould, the cast or part in relief being in all respects like the material of the rock of which it formed a part. Finally, that the footmarks belonged to a group of rocks which must be considered to have been produced by the same general causes which gave rise to the New Red Sandstone of Europe, and referrible only to that Sandstone. This Sandstone presents footmarks in many localities, though comparatively but a few years have elapsed since attention has been called to them. Some of the specimens have reached this country, and had they not, the information is well given by Dr. Buckland in his Bridgewater Treatise. The most remarkable of these footmarks is that of the Chirotherium from the quarries of Hessberg near Hildburg hausen in Saxony, and greatly resembles a fleshy human hand. These in the drawing and in the specimen which we have seen, are alternated right and left. Other footmarks have been observed by Mr. Link in the same sandstone, he having made out four species of animals, some of which are conjectured to belong to Gigantic Batrachians. Near Dumfries the footmarks of animals, probably tortoises, were obtained from the same sandstone: but as yet no tracks like those of New England have been discovered.

The facts, &c. which led to a different conclusion are these. First, that the forms assumed by fucoidal plants were numerous and imitative; some resembling the tail of a rooster, the *Cauda Galli*. Another which was like unto a large claw or paw, and which may have been a lusus naturæ, and the two specimens on the table of the Association which present in relief a distinct tri-partite form. There as they all appertain

to rocks of great antiquity in comparison with those of New England, it appeared more reasonable to believe that there might be resemblances as perfect as the fossils with a tri-partite character, were but approximations to the forms in question. That no trace of organic matter could be discovered by the eye, in the greater number of the Fucoides. In some such as the Harlani, they have been seen to be made up of small pebbles, presenting no little difficulty not to the manner only in which the organic matter was replaced, the external form being complete, but the nature of their material which could make so definite an impression and preserve its form entire. There are other facts which showed resemblance such as that the part in relief, was the part removed when the fucoide was attached to sandstone at its upper part. It may also be stated that the appendages to the heel of some of the New England tracks, might have been caused by a bird whose legs were feathered, but not to a wader, and they favoured their vegetable origin, for the appendages might readily be conceived to be either leaves or radials or both. From a comparative examination of the facts on both sides, your Committee unanimously believe that the evidence entirely favours the views of Prof. Hitchcock, and should regret that a difference had existed, if they did not feel assured it would lead to greater stability of opinion. To liken things to what we know in the nature of mind, the error from this tendency increases with ignorance and diminishes as knowledge increases, so that He that knoweth all things, as is self-evident, can commit no error when following this instinct of his being. The discoveries of Prof. Hitchcock were published at a period when the mind of those who embraced the negative side of the subject was preoccupied with the anomalous vegetation which many of the Silurian rocks of New York abound and to which provisionally the name of fucoid had been given. From their imitative character, and from finding a few specimens presenting a tri-parlate or tri-furcate form, &c. it appeared not only possible, but probable, that the impressions from Massachusetts and Connecticut were with greater propriety referrible to fucoidal bodies, than to those which Prof. Hitchcock had assigned them. We may here remark how essential it is that truth, or the facts which make manifest any truth, should first be presented to us, so readily is the mind impressed when not pre-occupied, and when a strong impression is made be it ever so false, it is no easy matter to free ourselves from it. From this circumstance we can readily forsee the advantage which future generations will possess over those of the present and especially those of former times. As the progress of knowledge is certain, each day will lessen error and enlarge the domain of truth, and should man be true to his permanent interests, error will finally cease to have existence.

HENRY D. ROGERS,
LARDNER VANUXEM,
RICHARD C. TAYLOR,
EBENEZER EMMONS,
T. A. CONRAD.

Glacio-aqueous Action between the Tertiary and Historic Periods, denominated in my Report, Diluvial Action.

Since the Section in this Report on Diluvium was written, I have been favoured, through the kindness of Professor Silliman of Yale College, with the perusal of a recent work by Professor Agassiz on Glaciers and Glacial action, entitled *Etudes sur les Glaciers*. I am indebted, also, to Dr. J. Pye Smith of London, for an abstract of three papers on the same subject, read last autumn before the London Geological Society, by Agassiz, Buckland, and Lyell. By the labours of these distinguished men, the whole subject of diluvium has been made to assume an aspect so new and interesting, that I am unwilling my Report should go out of my hands unaccompanied by a brief view of the facts and inferences concerning it. Perhaps I cannot better accomplish this object, than by giving, in the first place, an outline of the glacial theory, and its application to this country, in an extract from an Address recently published, which I gave before the Association of American Geologists at Philadelphia in April 1841.

"Beyond such independent inferences as these, (which had just been stated,) I confess, I have been of late years unwilling to go; and have regarded the numerous theories of diluvial action that have appeared, only as ingenious hypotheses. But it is well known that the Glacier Theory, originally suggested by M. Venetz, and subsequently by M. Charpentier, and more fully developed of late by Agassiz, is now exciting a great interest in Europe. To say nothing of geologists in this country, who have expressed themselves favorably towards it, it is surely enough to recommend it to a careful examination, to learn that such men as Agassiz, Buckland, Lyell, and Murchison, after long examination, have more or less fully adopted it; though on the other hand, it ought to be mentioned, that such geologists as Beaumont, Whewell, Sedgwick, Mantell, and others, still hesitate to receive it."

"In a country like ours, where no glaciers exist except in very high latitudes, and with the very indefinite accounts, which have hitherto been given of those in the Alps, it is not strange that this attempt to explain the vast phenomena of diluvial action by such an agency, should appear at first view, fanciful, and even puerile. But the recent work of Agassiz, entitled "*Etudes sur les Glaciers*," gives a new aspect to the subject. It is the result of observations made during five summers in the Alps, especially upon the Glaciers, about which so much has been said, but concerning which so little of geological importance has been known. Henceforth, however, glacial action must form an important chapter in geology. While reading this work and the abstracts of some papers by Agassiz, Buckland, and Lyell, on the evidence of ancient glaciers in Scotland and England, I seemed to be acquiring a new *geological sense;* and I look upon our smoothed and striated rocks, our accumulations of gravel, and the "*tout ensemble*," of diluvial phenomena, with new eyes. The fact is, that the history of glaciers is the history of diluvial agency in miniature. The object of Agassiz is, first, to describe the miniature, and then to enlarge the picture till it reaches around the globe."

"The glaciers are vast masses of ice, formed of melting and freezing snow, which are sent out from the summit of the Alps, by the force of expansion into the valleys below, sometimes to the distance of 12 or 15 miles. Those elevated and wide *plateaux*, called in Switzerland *Mers de Glace*, exhibiting only one sheet of ice, through which the crests and summits of the mountains sometimes rise like volcanos, are the grand source, or *birth-place*, of the glaciers. In their descent they plough their way through the soil, pile up pebbles and sand along their sides and at their extremities, and even upon their backs, which, upon the retreat or melting of the glaciers, constitute *moraines*, and correspond exactly in composition and shape to those

accumulations of gravel and bowlders that have been ascribed to diluvial action : The stones and sand frozen into the lower surface, also, like so many fixed diamonds, smooth and furrow the surface of the rocks in precisely the same manner as they appear over all northern countries. Vast blocks of stone are also conveyed without attrition, by the advance of the glaciers, and lodged in peculiar situations."

"From year to year the evidence has been increasing of the prevalence of intense cold in northern regions in the period immediately preceding the historic. The elephants and rhinoceros found in the frozen mud of Siberia, the arctic character of the few organic remains found in the post-tertiary strata of Scotland and Canada, as described by Lyell and Bowman, and of the borders of Lake Champlain, as described by Emmons and Conrad, and the vast extension of the ancient moraines in the Alps, are the evidence from which Agassiz infers that in that period all northern countries were covered with a vast sheet of ice, filling the valleys and extending southerly as far as diluvial phenomena have been observed. Glaciers would thus be found on mountains of moderate altitude ; and, indeed, he supposes that all the northern part of the globe might have constituted one vast *Mer de Glace*, which sent out its enormous glaciers in a southerly direction ; thus giving the same direction to the drift and striæ on the rocks. As these vast masses of ice, when the temperature was raised, melted away, immense currents of water were the result, which would lift up and bear along huge icebergs, whereby extensive erosions would be produced and blocks of stone be transported to great distances. Subsequently, lakes would be formed, where moraines had produced barriers, and clay and sand would there be quietly deposited by the waters which would be ultimately drained by the wearing down of the barriers of detritus."

"It is doing injustice to this theory to attempt so brief a description of it. A detailed account of existing glaciers which cannot here be given, forms the best preparation for a just appreciation of the theory. Admitting its truth in the main, let us see how it applies to the phenomena of drift in this country."

"In the first place, it explains satisfactorily the origin of those singular accumulations of gravel and bowlders, which we meet with almost everywhere in the northern parts of our country. I cannot doubt but that these are ancient moraines, just such as exist in Scotland and England. Were this the proper place, I could point out a multitude of localities of these, most of which have been a good deal modified by subsequent aqueous agency : but some of them retain the very contour which they had, as the ice melted away. The lateral moraines are perhaps most common, especially if with Dr. Buckland we regard our terraced valleys as modifications of these ; but I am confident that in our mountain valleys, the terminal and medial moraines are not infrequent. I have long been convinced that the agency of ice is essential to explain these accumulations ; but I was not aware that their antitypes existed in the moraines of the Alps."

"In the second place, this theory explains in a most satisfactory manner, the smoothing, polishing and furrowing of the rocks at different altitudes. All these effects are perfectly produced beneath the glaciers in the Alps ; nor can I conceive of any other agent, by which the work could be executed. It certainly was not done by currents of water alone."

"In the third place, it explains the transportation of bowlders, and their lodgment upon the crests and narrow summits of mountains ; and that often without having their angles rounded."

"In the fourth place, it accounts for the existence of deposits of clay and sand above the drift. For it furnishes the requisite quantity of water to fill the valleys, and the means of damming up their outlets for a season."

"In the fifth place, it shows us why these deposits of clay and sand are almost completely destitute of organic remains, either of animals or plants, although centuries must have been consumed in their formation."

"In the sixth place, it accounts for some rare and peculiar phenomena connected with diluvial action, which seem to be inexplicable on any other known principle. I shall name only two. The first is, that the northern slopes of some of the mountains of New England, although quite steep, and their summits rounded, exhibit scratches and furrows, which commence several hundred feet below their tops, and pass over them without losing their parallelism ; and yet the situation of the drift shows that these markings were made by an ascending, not a descending body. Such might be the effect, if the whole surface of the country were covered by a thick sheet of ice, expanding in a southerly direction. Of the other case, I have met with two examples in New England, and know not that they have been noticed elsewhere. In these cases the perpendicular layers of argillaceous and hornblende slate, covered in one case by 15 or 20 feet of drift, have been fractured to the depth of 10 or 15 feet, so as to be more or less separated, and so as to produce horizontal fissures, which are filled by mud ; while the laminæ of the rock are inclined at various angles. In short, it seems as if an almost incredible force had been exerted upon the surface, in an oblique direction. Such a force might be exerted by an immense mass of ice, in the process of expansion ; but I know of no other source from which it could have been derived." (*See Fig.* 83, *p.* 396, *and Fig.* 114, *p.* 560, *of this Report.*)

"On the other hand, there are features in the phenomena of diluvial action in this country, which are explained by this theory, in a much less satisfactory manner. One is, the southerly direction which our drift has taken, and the great distance to which it has been carried. It cannot be conceived that any single glaciers should have expanded several hundred miles in a southerly direction, especially over a surface which could have had scarcely no southern slope. Even if we admit a "Mer de Glace" in the northern regions so lofty, as in the beginning of the work to send glaciers a vast distance, yet the force seems to have continued to operate in the same austral direction, even to the bottom of our valleys. It is, however, probably true, that the great mass of our drift will be found within 15 or 20 miles of its origin, and that which occurs at greater distances may, perhaps, have been transported by powerful currents of water. It is almost certain that the sheets of ice which covered the surface according to this theory, must have been at least 3000 or 4000 feet thick ; because our mountains to that height have been swept over. Now, if as Agassiz and others suppose, the fall of temperature at the beginning of the glacial period was very sudden, why may not the return of the heat have been equally sudden ? If so, the most powerful debacles must have been the result ;* and as the ice would disappear most rapidly along its southern border, perhaps in this way a

* A curious example illustrative of this point has just been communicated to me by Rev. Justin Perkins, American Missionary at Oroomiah, in Persia, not far from Mount Ararat, in a letter of Nov. 6th, 1840. In giving an account of two very powerful earthquakes experienced on and around the mountain in the summer of last year, he says ; "the vast accumulation of snow which had been increasing on and about the top of the mountains for centuries, was broken into pieces, and parts of it shaken down on the

current in that direction may have been produced. And yet, I confess that I regard this theory more defective in not furnishing an adequate cause for the southerly course of our drift, than in any other point."

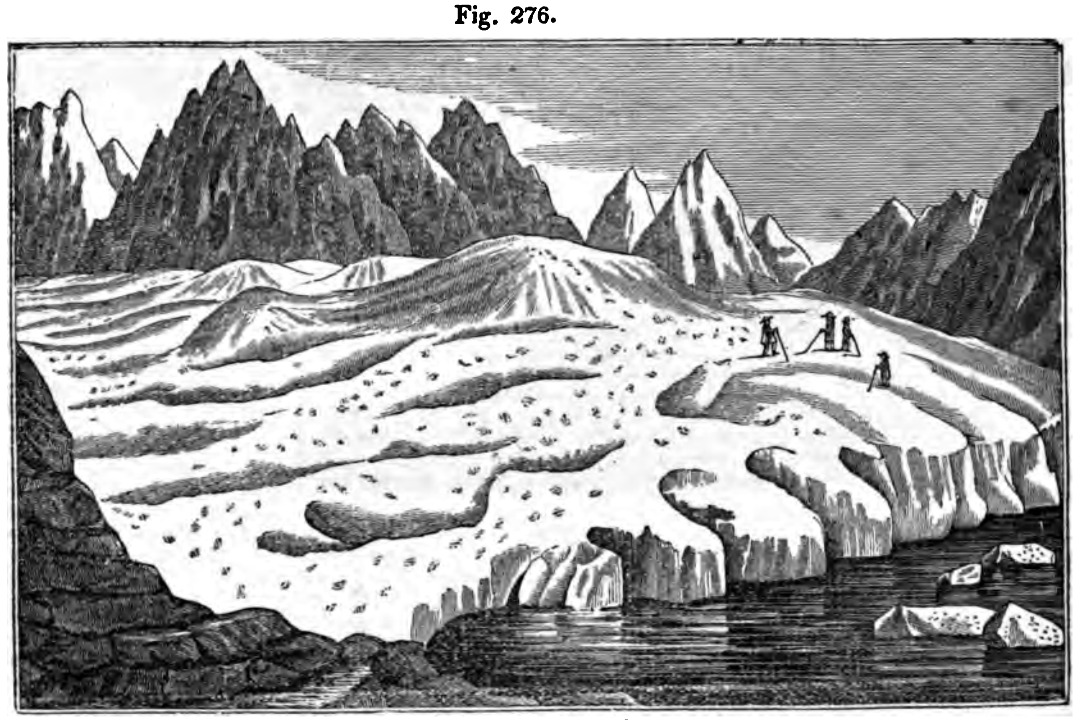
"I find another difficulty in explaining satisfactorily by this theory, how drift could have been often carried from lower to much higher levels; as it has been sometimes, without doubt. Thus, the Silurian rocks of New York and the quartz rock in the western parts of Massachusetts, have been carried over Hoosac and Taconic mountains and the Highlands of New York. It is easy to conceive how an immense sheet of ice, by its expansive power, should force portions of its mass to ascend declivities, of a few hundred feet; but not so easy to imagine them thus forced upward 1000 or 2000 feet.

"Another difficulty results from the fact, that some of the most remarkable of our moraines are found, not in valleys, but on the sea-coast, some of them 50 and others 100 miles distant from any mountain, much higher than themselves. I refer to those remarkable conical and oblong tumuli of drift, sometimes more than 200 feet high, which occur in Plymouth and Barnstable Counties in Massachusetts. I see nothing in this theory that will explain such astonishing accumulations in such circumstances; and yet their existence may not militate against its truth. For even the present mighty glaciers of the Alps, may give us but a faint idea of the advance and retreat of a sheet of ice thousands of feet thick."

"I do not mention these difficulties, (to which I might add more,) as any strong evidence against this theory. For so remarkably does it solve most of the phenomena of diluvial action, that I am constrained to believe its fundamental principle to be founded in truth. Modifications it may require: for it would be strange indeed, if it had already attained perfection, even in the skilful hands that have thus far formed and fashioned it. But I can hardly doubt that *glacio-aqueous* action has been the controlling power in producing the phenomena of drift. Having hovered so long over the shoreless and troubled ocean of uncertainty and doubt, I may be too ready to alight on what looks like *terra firma*. But should it prove a Delos, I have only to plume my wings again, when it sinks beneath the waves."

It may give a more definite idea of the nature of glaciers and of some of the phenomena connected with them, to insert a few cuts, copied on a reduced scale from the splendid drawings accompanying the *Etudes sur les Glaciers* by Agassiz. Fig. 276, exhibits the glacier of Aletsch, one of the largest in the Alps, where it enters the lake of Aletsch which it has formerly caused to overflow with wide spread havoc. Large blocks frequently break off from this glacier and float about as icebergs in the lake.

Fig. 276.

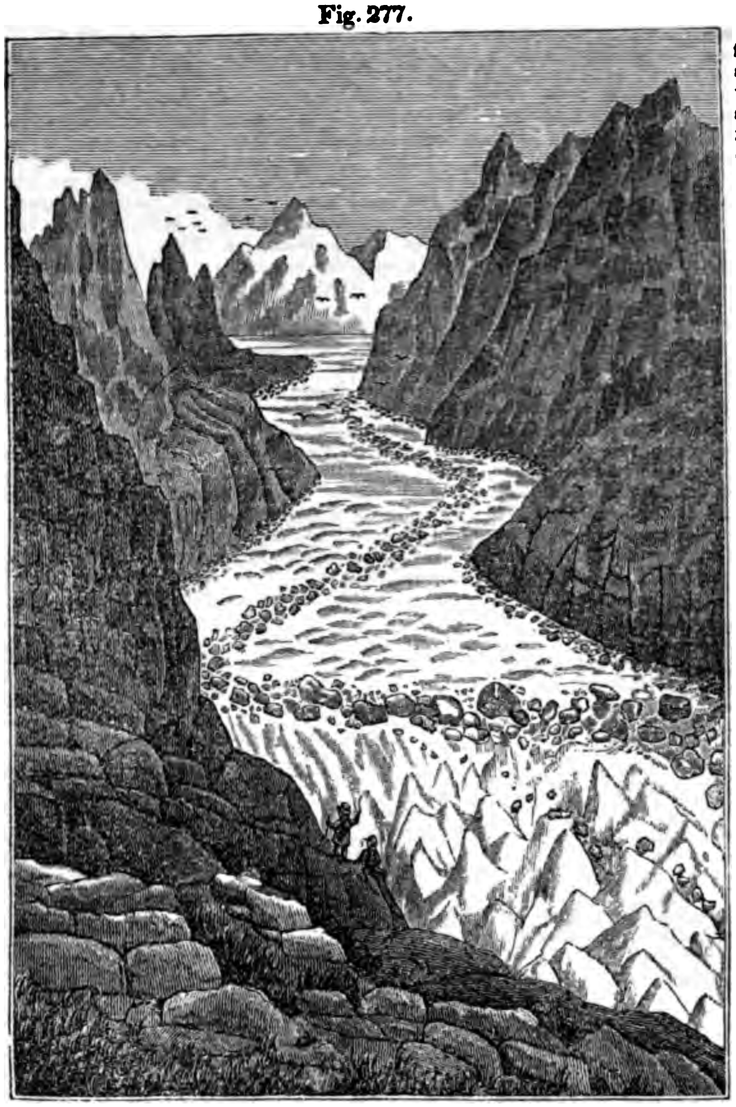


Glacier and Lake of Aletsch.

Fig. 278, exhibits the lower extremity of the Glacier of Viesch, with a distinct terminal moraine, which at the sides is connected with lateral moraines. From beneath the Glacier issues a stream of water, as is always the case in summer. This has worn a channel into the rocks below the glacier, and the surface of those same rocks is smoothed and striated by the former action of glaciers; so that here is exhibited glacial and aqueous action side by side. The conical bodies on the top of the glacier are needles of ice called *Aiguilles*, formed by the inequality of the surface beneath, and the melting of the ice above They are shown also on Fig. 277.

sides of the mountains in such immense quantities, that (it being midsummer and the snow descending down as far as a warm climate and suddenly melting,) torrents of water came rolling down the remainder of the mountain, and flooded the plain for some distance around its base."

Fig. 277.



Glacier of Viesch in the Alps.

In Fig. 277, we have a view of the upper part of the glacier, of Viesch, as it proceeds from the distant *mer de Glace*, and winds through the long valley. At its sides may be seen lateral, and on its top, medial moraines; considerably disturbed, however by the serpentine course of the valley.

Figs. 279 and 280, represent smoothed and striated masses of schistose serpentine, produced by the expansion of the glacier. Fig. 279, shows two sets of scratches, crossing each other at a considerable angle. Yet the striæ belonging to each set preserve their parallelism most perfectly.

Any one conversant with the smoothed and striated rocks of this country will be struck with their exact resemblance to the above. It is not unusual also, to meet with surfaces with two sets of striæ diverging slightly, as in Fig. 280. This is often the case, according to Professor Locke, upon the polished limestones of Ohio. Fig 281 is a case of this kind, copied from the crest of Mount Monadnoc in New Hampshire. The two sets of scratches diverge only 10,° and it is not common to see a much greater divergence.

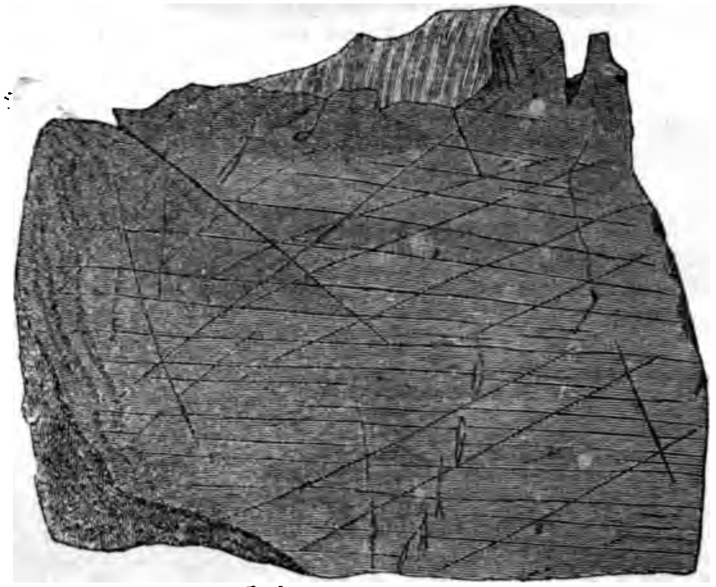
Another effect of glaciers has its counterpart among our diluvial phenomena. The ice so rounds off the angles of rocks as to give them an embossed form; and hence such rocks in the Alps were called by Saussure, *Roches moutonnees*. An example of this effect,—though less striking than others exhibited on the plates of Agassiz, (*Etudes sur les Glaciers*,) is shown on Fig. 277, at its lower part, and on Fig. 278 more distinctly. This same appearance is frequent upon the rocks of Massachusetts: but one of the most distinct examples that I have ever seen, occurs on Mount Monadnoc in New Hampshire. A large part of the crest of that mountain, and its northern and northwestern slopes, are covered with these protuberant and rounded rocks, whose surfaces often show distinct striæ. An attempt is made in Fig. 282, to represent the aspect of one spot about 5 rods square on the crest of the spur of Monadnoc that runs southwest from the body of the mountain. In taking the sketch the eye was directed southeasterly, which was the course there taken by the glacial agency. Hence the protuberances appear more like spherical domes than they are in reality; because they are generally much longer in a southeast and northwest direction than in any other. This spot is not less than 600 or 700 feet below the summit of the mountain; but the same appearance is common even almost to the apex.

On page 389 of this Report, I have given a brief account of diluvial action on Monadnoc, derived from my assistant, Mr. Abraham Jenkins, Jr. The interest which his description excited, has led me within a few days past to visit that mountain, and I found it prolific in the marks of former glacial action. It consists of a ridge of mica slate, running nearly S. W. and N. E. near whose center rises a vast pile of naked rock, several hundred feet above its northeastern and southwestern wings, which are also in a great measure naked. On almost every part of it, from its base to its summit, it bears the marks of a powerful abrading agency: and the region around the mountain, the hills as well as the valleys in its vicinity, abound with striated rocks, angular blocks of stone, and occasional moraines. The direction of the markings around Monadnoc and upon its southeastern part, is nearly N. W. and S. E.; but near the summit of the mountain they approach more nearly to the meridian, as near sometimes as 10° by the compass.

Fig. 278.

Glacier of Viesch, with terminal and lateral Moraines.

Fig. 279.

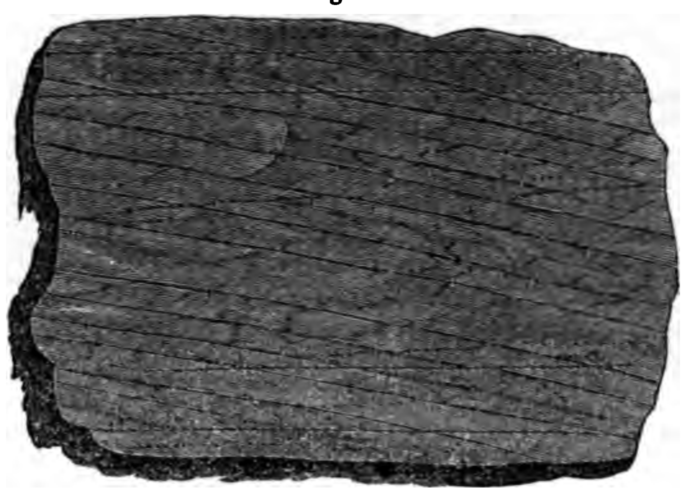


Rock striated by Glaciers.

Fig. 280.

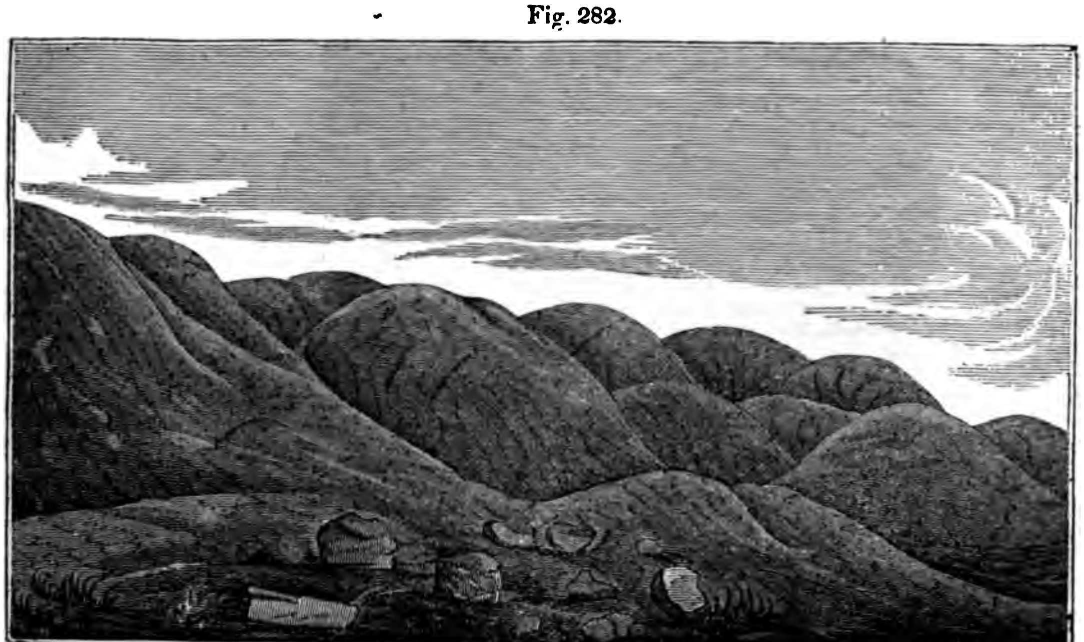
Rock striated by Glaciers.

Fig. 281.



Striated Rock: Monadnoc.

Fig. 282.



Embossed Rocks (Roches moutonnees): Monadnoc.

There are several peculiarities in what have been called the diluvial phenomena of this mountain, with which I should have been exceedingly perplexed, had I not read the recent *Etudes sur les Glaciers* by Agassiz. The striæ on the rocks are not as distinct as in many other places, and the difficulty of observing them is increased by the fact that over a considerable portion of the southwest part of the mountain, the strike of the laminæ of slate coincides very nearly with that of the scratches. Nevertheless, they may generally be distinguished by the practised eye, and on a large part of the mountain they cross the edges of the slate at a considerable angle. They are frequently visible on the sides of the ledges; and on the north side of the principal peak, they are sometimes seen on slopes from 20° to 70°. And what is still more unusual, they are seen on the southeast side of the principal summit, where the slope is steep, and several hundred feet below the top. But the *roches moutonnees* are the most striking peculiarity of the phenomena under consideration. Almost every part of the mountain, except its steep southeasterly side, is covered by these irregular rounded protuberances, which have almost every possible form; but their longer axis corresponds almost invariably with the direction of the grooves and striæ. Looking in a southeasterly direction they sometimes have the appearance represented on Fig. 282; but looking at them from other positions, they considerably resemble the swells of the ocean in a calm day after a storm. Frequently too the effects of ice in recent times, is seen in breaking up the surface of the rock more or less into fragments. If we face the northwest, even when among these rounded rocks, we see but little of the *moutonnees* appearance, because their southeastern extremities are not rounded: and there, indeed, (as at a spot few rods east of the summit of the mountain,) we see where large masses of the rock have been forced out of their places and carried away. Few loose transported blocks now remain upon the mountain.

The facts stated above relative to the occurrence of striæ on the north and south slopes of Monadnoc, might lead to the conclusion that they were the result of glaciers sliding down each way from the summit. But the fact that the *roches moutonnees* are rounded only upon their northwestern side, shows that the force which has produced these effects had a southeasterly direction. Indeed, I see no way to avoid the conclusion that the ice, which probably was the agent, must have been forced upward over the top of this mountain. I descended on the north side only a few hundred feet, but could see downward nearly to the bottom, and the same appearances presented themselves as near the top. Were the whole of the surrounding region covered with a vast sheet of ice, I can easily conceive how its expansion might have accomplished such a work. Indeed, so nearly irresistible must such a force have been, that either the mountain must have been crowded out of its place, or the ice have been swelled upward and forced over it. Such an operation must have broken the ice considerably, and this may explain the irregularity of its action towards the summit of the mountain, which is greater than I have witnessed in any other place.

If these views are correct, we cannot probably infer that the sheet of ice which covered New England was quite as thick as the height of Monadnoc; because it might have been swelled up considerably at this place. But the marks of its action at the top of the mountain are too striking to suppose the swell to have been very much above the general surface: otherwise the ice would have been tilted over and left no trace of its action. The downward force at the top must have been nearly as great as in any other part, and therefore a great thickness of ice must have been forced over it.

The important bearing of these details upon the theory of glacial action, is the reason I have given them; although Monadnoc lies a few miles out of the limits of the state. But whatever glacial action has taken place there, we may be quite sure has extended into Massachusetts. And indeed, I have pointed out similar phenomena there in the following Report.

Moraines.

After reading the work of Agassiz on Glaciers, and an abstract of the papers of Agassiz, Buckland, and Lyell, on the evidence of former glacial action in Scotland and the north of England, I cannot doubt but ancient moraines are scattered all over New England. The most remarkable of these I have described and figured in this Report. (See Wood Cuts, figs. 15, 19, 73 and 74, and Plate 3.) In the work of Agassiz I do not indeed find a description of any of those singular insulated or grouped tumuli of sand and gravel, which are so common in this country, and some of which are shown in the drawings above referred to. But it cannot be doubted that Dr. Buckland describes the same phenomenon in Scotland, when he says that "thirty or forty round-topped moraines, from 30 to 60 feet high, are crowded together like sepulchral tumuli," and he adds, that "they exactly resemble some of the moraines in the valley of the Rhone, between Martigny and Loek." Similar accumulations are common, according to him, in Scotland. I regret that he has not described under what peculiar circumstances such singular moraines are formed: for I own myself perplexed to conceive how: especially as the largest examples occur with us far away from any elevated land. I refer to those in Plymouth and Barnstable Counties. And yet, I shall be likely to regard the fact, that without any definite knowledge of the action of glaciers, I have in this Report called in the aid of ice to explain these mounds of gravel and sand, as some presumption in favor of their glacial origin. But how came such enormous moraines to be found in the low and comparatively level country where they exist? Is it possible that the whole of Cape Cod is nothing but a vast terminal moraine, produced by a glacier advancing through Massachusetts Bay, and scooping out the materials that now form the Cape? In this case the moraines at Plymouth and Truro would form a part of the lateral moraines, and probably most of Nantucket and Martha's Vineyard might be regarded as moraines of the same glacier, when it extended farther south. But the fact that laminated clay occurs so often upon the Cape, is a strong objection to such an hypothesis. The occurrence of so many ponds in connection with the moraines of Plymouth, Sandwich, and especially Falmouth, is readily explained by the glacier theory; since such effects are often thus produced in the Alps.

My attention was called to the new views of this subject, in season to mark on the proof sheet of Plate 53, which exhibits some of the phenomena of drift in Massachusetts, the most remarkable examples of moraines occurring in the State. These have, indeed, been described under another name in the following Report. It will be seen that many of the most remarkable of these occur far away from mountains and valleys, in the eastern part of the State, as at Truro, Sandwich, Falmouth, Plymouth, Wrentham, and Groton. Interesting examples exist, also, in Andover; but here the country is more uneven. As we proceed to the more hil-

ly parts of the State, it must be confessed that the moraines are the largest and most striking at the foot of the mountains, and especially near gorges in the valleys. The more elevated parts of country are, indeed, often thickly strewed over with loose blocks; but generally they are not much rounded, and appear as if they resulted from medial moraines, very much scattered. Essex county abounds with such examples, particularly on Cape Ann. (See Figs. 27, 28.) They abound also over the greater part of Worcester county, particularly as we ascend the western slope of Worcester valley.

So far as I have been able, I have recently re-examined the accumulations of gravel and bowlders in the State, to see whether they could be explained by glacial action. I find it often very difficult to recognise the different sorts of moraines; but think the lateral moraines most common and distinct. Thus, along the whole extent of the great valleys of Connecticut and of Berkshire county, we find lateral moraines evidently considerably modified and enlarged by those at the *debouche* of the smaller lateral valleys. The moraine on the western side of these great valleys is far less striking than on their eastern side. I cannot explain this fact, except by saying that the force which formed these moraines, acted in a southeasterly direction, so as to cross the principal valleys (as a glance at Plate 53 will show,) at a considerable angle. But it is not so easy to see how this is consistent with the idea that the moraines were formed by glaciers passing longitudinally through these valleys.

In the south part of Montague and northwest part of Leverett, is an interesting group of moraines. A narrow valley intervenes here between Mount Toby on the west, and the primary hills on the east; and it is at the entrance of this valley on the north, that we find both terminal and lateral moraines. The most southerly of these are pushed a considerable distance into the valley, the detritus (mostly gravel,) showing a northern origin. But the largest accumulations are a little north of the opening of the valley: as if the detritus had been pushed thus far, but could not be forced into the narrow valley. As we follow the valley southerly, we find remnants of lateral moraines wherever a recess exists protected by the salient sides of the valley. Towards its southern part, a wide field of many hundred acres, entirely level, is strewed over with rounded stones, 4 or 5 inches in diameter, either by glacial or aqueous action: an occurrence which I have scarcely met any where else. Large quantities of sand and some gravel are pushed southerly a little beyond the opening of this valley, into Sunderland and Amherst; but whether by glacial or aqueous agency I am uncertain: probably by both.

Between the eastern extremity of Holyoke and the primary ranges in Belchertown, is a narrow gorge where we witness moraines similar to those in Montague. In my report I have described three ponds situated in this gorge, in such a manner as to empty at both extremities. I am now satisfied that the different ponds resulted from several terminal moraines, produced by a retreating mass of ice. North of the gorge for several miles, we find extensive moraines, which might perhaps be regarded as vast lateral moraines, though I apprehend here was a blending of terminal and lateral moraines. In this group occur the singular tumuli and tortuous ridges of gravel, exhibited imperfectly in Fig. 73 of this Report.

On the east side of the gorge above described, we find moraines at a much higher level than those just described; and from this case, as well as others, I infer that the glacial action must have taken place at different levels. In other words, one mass of ice must have advanced southeasterly and have produced the more elevated moraines, while yet the lower part of the valleys were filled with ice, which adhered to the surface. If such were the case we see why it is that the moraines are so blended and irregular. I acknowledge, however, that the upper moraines may have been pushed to their present height by the expansive force of the ice, even from the bottom of the valleys; and the lowest ones have been produced by its retreat. The remarkable denudation of Mount Holyoke, however, described on page 389, of the following Report, I cannot explain without supposing the surrounding valleys filled at first with ice nearly to the top of that mountain, and then that another mass of ice, loaded with detritus, was slid over this surface, and commenced the work of furrowing out the remarkable valleys existing on its top. This would account for the parallelism preserved by those valleys; (called in Switzerland *Lapiaz or Lapiz.*) but the work must have been afterwards carried on partly by water, loaded probably by ice and detritus, as the ice gradually melted away. For such troughs (*Lapiaz*) in the Alps are found due in a measure to water. And yet, the denuding effects of ice must have continued even to the bottom of these valleys: for their sides show those peculiar striæ that can be the result only of the advance of masses of ice. In short, it seems to me that the striated and polished rocks, the *lapiaz*, or valleys of erosion, and the moraines of New England, show, that almost to the commencement of the historic period, there was a conjoint action of ice and water: And if the ice must have been 2000 or 3000 feet thick, it could not have melted away without the production of immense currents. Indeed, the term *diluvial* would probably be scarcely a misnomer, as applied to the last part of what seems to me now more appropriately termed the *glacial* period.

Through the middle of Amherst, from Mount Toby to Mount Holyoke, not less than eight miles, there extends a high and broad ridge of gravel and bowlders, interrupted, however, by two small streams and other depressions. On the west side of this ridge, lies the valley of Connecticut river: and on the east, a narrow valley separates it from the high hills of Pelham. Rocks in place sometimes rise through the gravel of this ridge and I am inclined to believe that the drift ought to be regarded as the union of two lateral moraines, (which, if I understand it, forms a medial moraine,) produced by glaciers in the two valleys above named. But this ridge is a good deal broken, and several minor ridges appear as if they might have been parts of terminal moraines. Of this description is the hill on which stands the College. But here, as in other parts of the state, it is impossible, I apprehend, so far as I can judge from the accurate description of Agassiz, to trace out such distinct moraines as exist in the Alps. Indeed, this writer says, that when he advanced beyond the valleys of the Alps, he could not find terminal moraines: and that "in open valleys and broad plains the phenomena of the moraines is completely changed from what it is in the narrow valleys of the Alps."

One of the changes to which the moraines have in some places been subject in this country, is that produced by the subsequent action of currents of water. In this way the detritus has been removed from the moraine where it was originally left, and redeposited by water; and hence the examples which I have given in this Report of a stratified and laminar arrangement of the sand and gravel of our drift. In this way, also, tumuli may have been formed out of lateral moraines by streams of water descending from the neighbouring hills: as perhaps may have been done in the formation of the tumuli in North Adams, sketched on Plate 3, and those on Figs. 15 and 19: though I doubt whether the last example was thus produced. I suspect it to be rather a part of a terminal moraine.

Moraines are abundant in the west part of Northampton, commencing at Round Hill, and in the east part of Granby, at the foot of Belchertown hills. But I have not found time to examine them with sufficient care to go into details.

Upon the whole, I think that the most striking examples of moraines in the mountainous parts of Massachusetts, occur where smaller lateral valleys intersect larger ones. I have mentioned one case of this kind in Amherst. Another good example is in Athol, a little north of the middle of the town, where the two branches of Miller's river unite. If I mistake not, several terminal moraines may be seen there, cut through by the river. The principal part of the drift appears to have been brought down the valley running north and south. Other examples occur on the east side of the principal valley in Berkshire, as we ascend Hoosac mountain through the lateral valleys that *debouch* in Lee and Dalton. Similar phenomena may be seen all along the Western Slope of Hoosac mountain, where the moraines and the detritus of moraines and the erratic blocks are exceedingly abundant.

Dr. Buckland regards the "parallel terraces" of Scotland, as "the effects of lakes produced by glaciers." In regard to similar phenomena in Massachusetts, described in this Report under the name of *terraced valleys*, I do not feel prepared to give a decided opinion. I will only refer to the terraces seen in the basin of Deerfield meadows. The most elevated of these are certainly composed almost wholly of horizontal layers of clay, deposited above the drift, which clay was subsequently carried away from the central parts of the valley, so as to leave a margin of clay. In this case no glacial agency could have been concerned, except perhaps to form the lake in which the clay was deposited. I think the terraced valleys in Westfield will be found similar to those in Deerfield. But others may have been produced by ice, whose moraines were subsequently modified by water.

To conclude: the theory of glacial action has imparted a fresh and a lively interest to the diluvial phenomena of this country. It certainly explains most of those phenomena in a satisfactory manner. It seems to me, however, that the term *Glacio-aqueous action* more accurately express this agency than the term *glacial action*: for the effects referrible to water are scarcely less than those produced by ice. I could wish that the theory gave a more satisfactory explanation of the southerly direction taken by the drift. Perhaps this is a point which can be only hypothetically solved. It may have been connected with the cause which introduced the glacial epoch. Whether this came in suddenly, as Agassiz supposes, or slowly, as Lyell maintains, we know of no cause now in operation that could have produced the change from a tropical to more than an arctic climate, and then back again to a temperate climate. Is it possible that the earth, after having assumed its present spheroidal form, and nourished successive races of animals and plants in some genial sphere, was suddenly deprived of external light and heat, and of its motion on its axis, and exposed to the severe cold of the celestial spaces (—58° Fahr.) Its waters would retreat towards the poles and become ice. Let it next be placed in its present orbit and commence its present motions: and would not the ice, as it melted, both from its expansive and centrifugal force, take a southerly direction? But I forbear: for enough of dreamy hypotheses on this subject have already had an ephemeral existence, and passed onward into the caves of oblivion.

Additional Errata.

p. 356, line 6 from top, for *most* read *not*.

p. 475, line 4 from top, for *rarely* read *nearly*.

posed in many cases of the very gentlemen to whom I formerly resorted for help, I may now pass by these subjects, and confine my attention to our Mineralogy and Geology.

THE GEOLOGY AND CHEMISTRY OF SOILS.

The Economical Geology of the State will first receive attention. This will embrace the two first objects of my commission as stated above. The subject of Soils—their origin and nature—analysis and amelioration—sometimes called Agricultural Geology—will first come under consideration.

Origin and Nature of Soils.

All geologists and chemists agree in regarding soils as the result of the abrasion, disintegration, and decomposition of rocks, with the addition of certain saline, vegetable, and animal substances. Ever since the deposition of rocks, various agents have been operating upon them to wear them down, to cause them to crumble or disintegrate, and often to decompose them into their proximate or ultimate principles, while they have been constantly receiving vegetable and animal substances with soluble salts. The earthy portions, however, always constitute by far the largest part; and hence, if we know the composition of the rocks whence they were derived, we shall know the earthy and metallic constituents of the soil. Now we find that nearly all the rocks which exist in large quantity, are composed chiefly of silica, alumina, lime, and oxide of iron: and these are the ingredients that are found almost invariably in soils. Magnesia is also usually present in small quantity; as is also manganese in some soils. Silica is in the largest quantity, both in the rocks and the soils; alumina next; while the other ingredients are in much smaller proportion. I ought, also, to add potassa and soda; which are very widely diffused, though not usually in large quantity. To give a numerical statement, derived from numerous analyses, such rocks as most of those in New England contain 66 per cent, of silica, 16 per cent, of alumina, 6 or 7 per cent, of potassa, 5 per cent, of oxide of iron, and of lime and magnesia a less quantity: and the composition of our soils will probably be found to correspond very nearly with these numbers, with the exception, perhaps, of the potassa which may have in a good measure disappeared by the operation of vegetation.

A large part of most soils being merely rocks reduced to minute fragments without being decomposed, will as remarked above, be of the same chemical composition as those rocks. Now in almost all cases rocks are composed mainly of silicates; viz. the silicates of alumina, lime, magnesia, iron, potassa,

soda, &c. In a region where limestone predominates, we might expect, and do sometimes find, that a considerable proportion of the soil is made up of carbonate of lime. Yet this substance is more liable to decomposition than the silicates, and often a large part of it is converted by the action of living and dead vegetable and animal matter into other combinations. Thus decomposed manures form what is called geine or rather geic acid; and this unites with lime forming a geate of lime. Geates of alumina and magnesia are formed in the same manner. Living vegetables also contain generally sulphate and phosphate of lime; and by the decomposition of these vegetables, these salts will be widely disseminated through the soils. But this subject will be better understood when I have given further details.

Classification of Soils.

The above ingredients are combined in different proportions in the different rocks, so as to constitute several sorts. Hence we should expect, and in fact we find, a corresponding difference in the soils resulting from their decomposition. Indeed, with some exceptions, the geologist is able to ascertain the nature of the rock from the character of the soil that covers it. And I apprehend that it will not be difficult to point out the characteristics of the soils derived from the different rock formations of Massachusetts, so that they can be distinguished by those not familiar with practical geology. This Geological Classification is the only one which I shall attempt to give of our soils; and this seems to me all that is necessary, or useful, in addition to the common division into sandy, clayey, loamy, calcareous, &c. The following list embraces, it appears to me, all the important varieties of soil in Massachusetts.

1. Alluvium, from rivers.
   Do. peaty.
2. Diluvium, sandy and gravelly.
   Do. argillaceous.
3. Tertiary soil, argillaceous.
   Do. sandy.
4. Sandstone soil, red.
   Do. gray.
5. Graywacke soil, conglomerate.
   Do. slaty, gray.
   Do. slaty, red.
6. Clay slate soil.
7. Limestone soil, magnesian.
   Do. common.

8. Mica slate soil.
9. Talcose slate soil.
10. Gneiss soil, common.
    Do. ferruginous.
11. Granite soil.
12. Sienite soil.
13. Porphyry soil.
14. Greenstone soil.

A few paragraphs of explanation will, I trust, render these varieties of soil recognizable.

In general, if any one wishes to know where to find them, let him look at the Geological Map that accompanies this report, and he may conclude that the different soils cover those portions of the surface that are represented as occupied by the rocks from which they are derived. There is one circumstance, however, that prevents us from considering the boundaries of the rock formations as perfectly coincident with those of the soils. Diluvial action has removed nearly all the loose covering of our rocks in a southerly direction; often several miles; and more or less mingled the soils from different formations. Hence, where one formation lies north or south of another on the map, we may conclude that the detritus of the most northerly one has been swept southerly, or southeasterly, for several miles beyond the boundaries of the rock; and in few cases does the dividing line between two formations so exactly coincide with the direction of the diluvial current, that there is no overlapping and intermingling of the soils.

With common alluvial soils—the result of deposition from rivers,—every intelligent man is familiar. They are of course formed by the comminution of every kind of rock over which the stream that produces them happens to pass. These soils, I apprehend, owe their value chiefly to the fine state to which their component parts are reduced. In Massachusetts our alluvia are frequently coarse and quite siliceous.

Peat alluvium is composed principally of vegetable matter, and ought rather to be regarded as a manure than a soil. I include in it all those swamps that abound in decomposing vegetable matter, whether actually converted into peat or not.

Diluvial Soil is the most heterogeneous and wide spread of all soils, and strictly speaking it embraces nearly all our soils except alluvium: for nearly all of them have been moved and comminuted by diluvial action. But where a formation is so extensive that this diluvial agency has not transported the detritus derived from it beyond its boundaries, the soil may be regarded as belonging to that formation; and this is the case over a large part of the state: so that it will not be necessary to regard very extensive districts

of our soils as diluvium. I have not done it when it is possible to refer them to any other formation.

The most common variety of diluvial soil, and the poorest of the soils, consists of rounded pebbles and coarse sand, accumulated in situations where no existing streams could have carried them. I now also regard all those beds of clay and sand which occur in the state, except the plastic clay of the south-eastern part, as the result of the retiring diluvial waters; so that there will be an argillaceous and a sandy diluvial soil; such as occur extensively in the valley of Connecticut river, and which I formerly denominated the Newest Tertiary.

The tertiary soils are almost exactly like the two last described varieties of the diluvial, viz. argillaceous and sandy. Indeed, it is doubtful whether any character except position can distinguish them: nor is the distinction of any importance in a practical point of view. The tertiary soils occur only in a few limited districts, in Dukes, Barnstable and Plymouth counties: viz. wherever the plastic clay exists so near the surface, as to modify the superincumbent diluvial sand.

The sandstone soil is confined exclusively to the vicinity of Connecticut river. Most of the sandstone there is of a red color; some of it even a blood red; and its disintegration has produced a soil of the same aspect; so that even at a great distance, the redness is quite manifest. There is no soil that can easily be confounded with this, except some limited tracts of ferruginous gneiss soil in Worcester county, and of chocolate colored graywacke, and red compact feldspar, in the eastern part of the State. In a few towns, as in Granby, the sandstone soil is of a gray color, because the rock is gray beneath it.

The graywacke soil is confined to the eastern part of the State. Its color is mostly a deep brown; and it is capable of being made some of the best land in the State;-as will be evident when I refer to Dorchester, Roxbury, Brookline, Newton, Cambridge, the Bridgewaters, Taunton, Middleborough, Dighton, Somerset, &c. for examples of its most perfect development. In some of these towns the rock is chiefly a coarse conglomerate or plum pudding stone; and as this contains more calcareous matter than the slaty varieties, and decomposes more readily, probably it furnishes the best soil found over this formation. The slaty varieties occur in Quincy, Newton, Charlestown, &c. In the southwest part of Attleborough, the slate is of a chocolate color, and this peculiar hue is imparted to the soil. The same color prevails in some other places; but not extensively enough to produce any striking patches of this variety of soil.

The group of rocks underlying this variety of soil is denominated ***graywacke***, not because it has been proved to be identical with the graywacke of Eu-

rope; but because it seems analogous in composition and structure with the European rocks of that formation: and there is nothing yet discovered in regard to its position that proves its age to be different.

The tracts are very limited in Massachusetts, where well characterized argillaceous or roofing slate is fully developed: and hence we have but little genuine clay slate soil. Where it does occur, as in a few towns in Worcester and Middlesex counties, also in Bernardston, in Franklin county, it has the dark color of the slate; and is easily distiguished. It is capable of being made an excellent soil.

The limestone soil is confined to the county of Berkshire. I give it this name because it lies above limestone; not because it contains more of the salts of lime than other soils in the State. For to my surprise, I find that in general it does not. Much of it probably resulted from the disintegration of the mica and talcose slates that occur in large quantities along with the limestone in that county; and probably, also, the calcareous matter, which it did once contain, has been exhausted by cultivation. The magnesian limestone and the soil thence resulting, appeared to me more extensive in New Marlborough than in any other part of the county.

The mica slate soil, which occupies extensive regions in Massachusetts, as the Geological Map will show, is distinguished in appearance from the clay slate soil, chiefly by being of a lighter color. Yet since the two rocks pass into each other imperceptibly, so do these soils. And in the western part of Berkshire county, as well as in the mica slate region extending from Worcester to the mouth of Merrimack river, the mica slate approaches so near to argillaceous slate, that the soil above it might, without much error, be referred to the latter rock. Most of our mica slate soils are of a superior quality.

The talcose slate soil is rather limited, and not of the best quality; though it should be recollected that it occupies some of the highest parts of the State, and might at a lower level be more productive. The argillo-talcose slate soils of the Taconic range in Berkshire, are of a better quality. In appearance the mica slate and talcose slate soils can hardly be distinguished from each other; though in general the latter is of a lighter color and more sandy.

Gneiss soil occupies more surface than any other in the State: and were we to judge from its appearance, we should conclude it the poorest soil within our limits. In general, it is of a pale yellow color, and very sandy or gravelly. And, indeed, in many places it is very meagre and unproductive. But over a great part of Worcester county, for instance, it is of a very different character, being enriched probably by the potassa of the feldspar and mica in gneiss. The ferruginous gneiss soil contains so much peroxide of

iron, that in some towns, as West Brookfield, Sturbridge, Brimfield, Oakham, &c., it is of a perceptible red color when seen at a distance.

Since granite and gneiss are composed of the same ingredients, the soils which they produce will not differ. And in fact they do not in Massachusetts: so that probably there is little advantage in separating them.

Sienite differs from granite in taking hornblende into its composition, as well as being in general of a finer texture. The soil resulting from its decomposition is certainly more favorable to cultivation than that derived from common granite: as an example of which I may refer to nearly the whole of Essex county.

The compact feldspar, that forms the basis of porphyry, frequently contains an unusually large proportion of alumina, from 15 to 30 per cent. And although this is the hardest of the rocks around Boston, in many places it decomposes rapidly, and the resulting soil admits of high cultivation, as may be seen in Medford and Lynn.

The greenstone in the eastern part of the State is so intimately connected with sienite and porphyry, that the attempt to separate the soils resulting from them, is almost useless. Yet the structure of the greenstone is finer, and where it predominates, we find a good soil; as in Ipswich and Woburn. The greenstone associated with sandstone, near Connecticut river, has a more earthy aspect, and produces by decomposition a peculiar yet valuable soil, of a deep brown color, and abounding in iron. It is, however, but of limited extent.

Sir Humphrey Davy divides soils into Clayey, Loamy, Chalky, Gravelly, Sandy, Peaty or Mossy, Boggy and Heathy, and Moory: Chaptal makes a more simple division into Argillaceous, Calcareous, Siliceous and Sandy. These divisions are very convenient, and it is only for the sake of reference that I have adopted in their stead the geological classification described above.

System pursued in collecting Soils.

In executing that part of my commission which relates to the analysis of soils, I found it very difficult to decide upon the best plan for collecting them. My object was not to examine the soils of particular farms, or towns; but rather to point out the composition and character of the different classes of soils in the State. I therefore concluded to visit the different rock formations; and where I found the soils above them well characterized, to select specimens, in sufficient numbers, and over a sufficiently wide extent, to afford a fair representation of the different sorts of soils. Whatever might be found to be the characters of these selected specimens, from any particular

formation, I thought might be regarded as the characters of the soil in general over that formation; and to determine its extent, it would be necessary only to consult the Geological Map, with the statements in mind that have been made respecting diluvial action. And it is chiefly this consideration that led me to prefer the geological classification of soils. On this plan it seemed to me unnecessary to designate the particular farms from which the specimens were obtained.—I took care, however, in all cases, except those hereafter mentioned, to select my specimens from a cultivated ploughed field; about half way between the subsoil and the surface; and in a spot where the vegetable fibres had nearly disappeared by decomposition. I avoided, also, in general, the vicinity of buildings; especially barns: as I did also those fields where the soil had become very factitious by high cultivation; or where it was very sterile through neglect of culture. I endeavored to select spots where a medium state of cultivation existed; because I conceived that these would present the fairest average examples of the capabilities of our soils. And as most of the specimens were collected towards the close of summer, I could judge from the crops growing upon the fields, where the soil was in a medium state of cultivation. In a few cases I have purposely or accidentally taken specimens either from very poor or very rich spots; but such examples will be pointed out, when I come to give details. Roots, undecomposed manure, and large pebbles, were as much as possible avoided: and before proceeding to an analysis, I separated all the roots and pebbles larger than a quarter of an inch, with a course sieve. For although such matters generally exert some, and often a great influence upon the cultivation, yet it seems to me that their chemical examination can add little or nothing to what experience has already taught on this subject.

The soils were collected in tin canisters, which were labeled on the spot. Afterwards the specimens were spread out and exposed for several days to a warm sun and dry air, so as to expel all the moisture which could be driven off by natural evaporation. They were then returned to the canisters, and a portion taken for the various analytical processes which were adopted. After this, the residue was put into white glass bottles, which were sealed, numbered, and deposited in the State collection, along with other substances, such as marls, clay, quick much marsh mud, ochre, &c. This arrangement makes the specimens easy to be examined by the eye, without the danger of waste by uncorking the bottles.

Leading Objects of the Analysis of Soils.

The views that have been given as to the origin and nature of soils will enable us to make a threefold classification of their constituents. First, their

earthy and metallic ingredients, which are chiefly silicates: Secondly, the acids, alkalies, and salts, which exist originally in them, or are introduced by cultivation: and thirdly, the water and organic matter which they contain. The latter constitutes the principal nourishment of plants, derived from the soil; while the salts are necessary to prepare that nourishment to be taken up and assimilated by their delicate vessels. The earth serves as a basis of support for the plant, as a receptacle for the nourishment, and probably also, in connection with the roots, as a galvanic combination, for the development of those electrical agencies by which the food of plants is taken up and converted into vegetable matter.

By almost any method of analysis that can be adopted, the three leading objects above specified will be more or less combined. But as some of these methods have a chief reference to one of these points, and others to other points, it will be practicable, in the first place, to confine our attention mostly to the earthy constituents of soils; and in the second place, to examine more particularly their salts and organic matter.

Analysis of Soils by Sir Humphrey Davy's Method.

The method of analyzing soils proposed by the distinguished English chemist, Sir Humphrey Davy, in his Agricultural Chemistry, has been almost universally regarded as the best that has been invented. It consists in first driving off the water of absorption by a heat of 300°: Secondly, in boiling the soil in water, and suffering the coarser parts to settle, which are regarded as silica; while the finer, or aluminous portion, is suspended in the water, and is poured off: Thirdly, in determining by muriatic acid, the amount of carbonate of lime, if any be present: Fourthly, in burning off the organic matter of the finer part of the soil: Fifthly, in boiling the remainder in sulphuric acid, in order to dissolve the alumina and oxide of iron: Sixthly, in ascertaining the amount of soluble salts in the water employed for lixivation. The French Chemist, Chaptal, proposes essentially the same plan, though he renders it much more simple, by omitting the most difficult part; that is, the solution of the alumina and iron by sulphuric acid. The high reputation of Davy's rules led me to attempt their application to nearly half the soils which I had collected in Massachusetts: and the results are contained in the Table which follows.

Before presenting any analytical results, however, I wish to state the circumstances under which this part of the survey has been conducted. In some of the larger States of the Union, where geological surveys have been commenced, one or more chemists are constantly employed in the laboratory.

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No such course was adopted in Massachusetts: but the surveyor was directed, in general terms, to make an analysis of the soils, in his commission for a re-examination of the State. The question then arose in my mind, whether it would be possible, while carrying forward the other parts of the survey, to make a sufficient number of analytical investigations to be of much use. It was obvious that the time which I could devote to the subject, would not permit me to perform very numerous analyses with the extreme care and multiplied repetitions which the precision of modern science demands, in order to employ the results in settling the atomic constitution of bodies. Yet it occurred to me, that the objects of the Government might be in a good measure accomplished, if the results were not of the extremely accurate character above described. By a variety of means, some of which are described in the subjoined note,* and by the most laborious and devoted attention to the subject, I have been able to present a great number of results, which I trust will be found sufficiently accurate for the purposes I had in view. I do not mean that the processes were not conducted with care; and that I did not repeat them. Very many of them have been repeated again and again; especially whenever there was reason to suspect any material error in the results. Nor do I mean to say, that none of these results are sufficiently accurate to form the basis of scientific reasoning. As to that point, scientific men can judge when they examine my analyses: But I do not offer my conclusions for such a purpose: and wish, as an act of justice to myself, to have it understood, that the standard by which my analyses ought to be tried, is that of their practical value in an economical, not in a scientific point of view.

The following Table exhibits the results of the analysis of 61 soils, selected from the different formations in the State. For convenience, they are all

* The arrangement by which I was enabled most successfully to facilitate the process of analysis, consisted in providing means for carrying on ten similiar processes together. I made ten compartments upon a table, each provided with apparatus for filtering and precipitation. Ten flasks and ten evaporating dishes were also numbered, as well as ten common crucibles, with a circular piece of sheet iron, pierced with ten holes, and numbered to receive the crucibles. An oven of sheet zinc, with double sides, was likewise fitted up so as to receive ten filters, and to admit a thermometer. The sand bath was also made large enough to admit the ten flasks. By this arrangement, all the important processes in the analysis of soils, by the methods of Sir H. Davy and Dr. Dana, except weighing, could be conducted together, and almost as rapidly as if only one had been carried on. Even the weighing was in this way much facilitated, as any one can easily conceive. I applied also, so far as it was possible, the same method in conducting analyses in a more accurate manner. I supplied myself with four or five platinum and silver crucibles, which being charged, their contents were either fused together in a charcoal fire, or in succession over a spirit lamp. This process was repeated until ten substances were obtained in a state of fusion. Afterwards the processes were conducted as above described; except that the ignition of the results was performed over the spirit lamp. It is easy to see how by this arrangement a great saving of time was made.

I would not forget to mention also, my indebtedness to the faithfulness and perseverance of my chemical assistant, Mr. Abraham Jenkins, Jr. of Barre.

reduced to the same standard, viz: 100 grains; and the small loss, which inevitably attends this mode of analysis, has been apportioned among the several ingredients.

No.	NAME AND LOCALITY OF SOIL.	Water of Absorption.	Organic Matter	Siliceous Deposite from Water.	Aluminous Deposite from Water.	Salts soluble in Water.	Composition of the Aluminous Deposite. Silica.	Alumina.	Oxide of Iron
1	Alluvial Soil; Deerfield.	3.0	5.5	29.8	61.7		55.2	3.5	3.0
2	do Northampton.	3.4	5.1	32.8	58.5	0.20	51.7	3.4	3.4
3	do Deerfield.	2.0	4.5	43.2	50.3		44.1	3.7	2.5
4	do Northampton.	3.0	3.0	74.8	19.0	0.15	16.2	1.3	1.5
5	do Northfield.	2 7	4.2	43.9	49.2		44.0	2.4	2.8
6	do Northampton.	2.1	3.2	40.0	54.7		51.0	1.7	2.0
7	do West Springfield.	1.3	5.0	67.9	25.4	0.20	21.6	1.2	2.6
8	do Stockbridge.	1.9	4.9	83.5	9.7		7.4	1·3	1.0
9	do Hadley.	4.4	6.6	45.6	43.0	0.20	39.4	1.6	2.0
10	do Sheffield.	2.2	5.5	62.1	30.0	0.20	23.9	3.0	3·1
13	Tertiary Soil, Argillaceous; Springfield.	3.3	10.0	47.8	38.7	0.16	32.7	3.5	2.5
16	do do Barnstable.	2.6	9.4	47.2	40.8	0.05	29.8	6.7	4.3
18	do Sandy; Wareham.	1.2	0.4	98.4	0.0				
19	do do Springfield.	1.7	2.7	92.8	4.8		2.4	1.3	1.1
20	do do Barnstable.	1.0	0.2	98.3	0.5				
21	do do Gloucester, (Squam.)	0.15	0.0	99.6	0.0	0.20			
23	Sandstone Soil, red; Longmeadow.	2.4	4.4	79.0	14.0	0.20	10.6	1.3	2.1
25	do do West Springfield.	2.6	6.1	50.5	40.4	0.38	32.6	4.2	3.6
26	do grey; Granby.	2.8	3.9	37.3	55.9	0.13	48.6	2.6	4.7
27	Graywacke Soil, Conglomerate; Dorchester.	3.0	7.8	61-7	27.5		19.3	4.7	3.5
30	do do Walpole.	2.2	7.6	56.0	34.1	0.10	28.5	3.1	2.5
31	do do Dighton.	1.6	5.2	59.3	33.8	0.10			
32	do Slaty; Middleborough.	1.7	6.0	69.2	23.0	0.10	17.0	2.2	3.8
35	do do Watertown.	4.1	9.1	45.6	41.0	0.20	31.9	4.1	5.0
36	do do Halifax.	1.5	5.5	82.6	10.3	0.14	6.9	2.3	1.1
38	do do Taunton	2.0	6.0	76.4	15.5	0.10	11.1	2.8	1.6
40	do do, red; Attleboro,' S. W. part.	3.2	9.7	43.0	44.0	0.12	27.5	8.0	8.5
41	Argillaceous Slate Soil; Lancaster.	3.0	9.5	59.3	28.1	0.09	23.1	3.1	1.9
43	do do Townsend.	3.5	11.5	70.5	14.2	0.32	7.2	4.5	2.5
44	Limestone Soil, Magnesian; New Marlborough.	1.9	5.8	67.6	24.6	0.12	16.6	4.0	4.0
45	do common; Lanesborough.	2.5	7.5	61.3	28.5	0.20	17.0	4.5	7.0
47	do do North Adams.	1.4	5.1	73.9	19.5	0.14	13.5	3.5	2.5
50	do do Pitsfield.	4.0	9.0	63.7	23.2	0.10	16.2	4.0	3.0
51	do do Sheffield.	3.9	7.2	67.7	20.9	0.32	11.9	5.0	4.0
54	Mica Slate Soil; Webster.	2.8	10.4	51.2	35.5	0.14	27.9	5.4	2.2
56	do Stockbridge mountain.	3.1	7.4	59.7	29.7	0.10	19.7	4.7	5.3
58	do Bradford.	3.0	10.4	44.0	42,3	0.25	32.3	5.8	4.2
59	do West Newbury.	3.0	7.6	65.2	24.1	0.10	16.2	5,1	2.8
60	do Methuen.	1.4	4.0	83.0	11.6		6.4	1.0	4.2
63	do Conway.	1.4	6.3	67.7	24.5	0.10	18.3	4.3	1.9
65	Talcose Slate; Charlemont.	2.5	6.0	72.0	19.4	0.08	12.7	1.9	4.8
67	Talco-micaceous Slate Soil; Hancock.	2.8	9.7	44.8	42.7		30.4	7.6	4.7
70	Gneiss Soil; Bolton.	2.8	7.3	63.5	26.2	0.25	22.2	2.3	1.7
71	do Uxbridge.	2.5	7.0	37.8	52.5	0.19	44.8	4.3	3.4
77	do Rutland.	3.8	10.2	58.7	27.0	0.26	21.0	3.5	2 5
79	do Royalston.	4.0	9.0	67.6	19.3	0.14	14.9	3.2	1.2
89	do Grafton.	3.0	7.7	40.1	49.0	0.20	38.9	6.7	3 4
90	do Brimfield	2.1	6.9	70.9	20.0	0,10	15.9	2.9	1.2
93	do Becket.	4.0	9.0	64.6	22.0	0.40	16.6	3 4	2.0
96	do Sturbridge.	1.8	5.7	77.1	15.2	0.22	11.3	2.3	1.6
104	Granite Soil; Andover.	3.3	9.5	54.4	32.6	0.20	26.9	3.9	1.8
106	Sienite Soil; Marblehead.	3.7	8.9	61.5	25.8	0.10	20.0	2.3	3.5
108	do Gloucester.	1.7	4.8	80.0	13.4	0.13	9.6	2.1	1.7
109	do Lexington.	3.7	10.0	46.7	39.4	0.16	34.0	3.0	2.4
111	do Newbury.	3.5	7.5	60.1	28.8	0.12	22.2	4.4	2.2
112	do Dedham.	4.3	9.9	46.3	39.3	0.17	31.4	5.1	2.8
117	do Marshfield.	2.0	5.2	68.7	24.0	0.11	19.2	2.7	2.1
120	Porphyry Soil; Medford.	4.1	10.6	51.9	33.2	0.15	27.7	3.5	2.0
122	do Lynn.	4.0	8.5	46.4	40.8	0.30	34.6	3.7	2 5
124	Greenstone Soil; Woburn.	4.0	10.3	46.7	38.9	0.15	33.7	2.3	2.9
125	do Deerfield.	2.0	7.0	32.7	58.2	0.10	30.5	3.3	4.4

Explanation of the preceding Table with remarks.

The numbers in the first column of the preceding table, denote the specimens of the soils deposited in the State collection: and the second column points out the name and locality.

However thoroughly soils are dried in the sun, a quantity of water still adheres to them, which cannot be entirely driven off, until they are heated to nearly 300° of Fahrenheit's thermometer; or to the point where paper begins to turn brown. This was the way in which the numbers in the third column were obtained, by heating 100 grains to that point and noting the loss of weight. Highly siliceous soils retain but very little of this water of absorption, while from highly aluminous ones, it is not all driven off by heating to 300°. The power of soils to retain water, however, depends much more upon the quantity and character of the organic matter which they contain, than upon their mineral composition, as I shall endeavor to show hereafter.

After driving off the water of absorption, the soil was heated to redness, and continued in that state until every thing combustible was burnt off. The loss of weight showed the quantity of organic matter; and thus the fourth column was formed.

The fourth column in the above table presents one fact worthy of notice. It seems that our alluvial soils, although deservedly celebrated, contain less of organic matter than almost any other in the State. The principles above suggested explain their fertility in consistency with this fact: but it shows us, if I mistake not, that such soils, if not constantly supplied with manures, either by the overflowing of rivers, or by the farmer, will be sooner exhausted than almost any others.

The numbers in the fifth and sixth columns were obtained in the following manner. One hundred grains of the soil were boiled a short time in a glass flask in water, and after cooling, this was agitated until the soil was all diffused through the water. As soon as the agitation of the water had ceased, it was poured off along with the finer parts of the soil that did not settle at once. The portion that remained usually consisted of siliceous sand, while that which was left suspended in the water, was much more aluminous, and constituted the finest and most important part of the soil. In the present instance, this deposite is in larger proportion than is usual in analysis, because it was poured off immediately after the agitation had ceased, under an impression that by waiting two or three minutes, as is usual, other and more important substances than silica may settle to the bottom of the vessel. In deed, I found this to be the case in some instances when the light matter was

poured off immediately. Thus, the red sandstone soil, No 23, from Longmeadow, gave only 14 grains of aluminous matter, and 79 grains of siliceous. By digestion in acid, the 14 grains yielded only 1.3 gr. of alumina and 2.1 gr. oxide of iron. But by treating the 79 grains of siliceous matter in the same way, it produced 7.5 grains of alumina and 4 grains peroxide of iron. Such cases teach us that this mechanical separation of the siliceous and aluminous matter is not a little uncertain: although in general it must be confessed, that when the lighter part was poured off immediately, the remainder was chiefly siliceous sand.

It is not the object of this process however, to show us the quantity of silica and alumina in a soil: but rather the amount of finely divided matter. For the best soils are found, in general, to abound in such matter: although it may become excessive, rendering the soil impervious to air and moisture. This is a principal defect in highly argillaceous soils. But from the preceding table it appears, in my opinion, that the soils in Massachusetts are in general too coarse rather than too fine. Being derived chiefly from primitive rocks, they resist comminution and decomposition more than the secondary rocks. I am satisfied that the principal excellence of our alluvial soils depends more upon their finely divided state than any thing else: for, as I have already in part shown, and shall show farther in the sequel, they must yield in value in some important respects, to our upland soils. And even as to their fineness, they are much coarser than many of the rich alluvia of the Western States; though it may be doubted whether for most crops they are on this account the less valuable.

The term salt, in chemistry, has a much more extended meaning than in popular language. Thus common limestone (carbonate of lime) and gypsum (sulphate of lime) are properly denominated salts, as is also phosphate of lime and chloride of calcium (muriate of lime). All compounds of any acid with lime, magnesia, alumina, potassa, soda, &c. or of chlorine with their metallic bases are salts: and some of these are soluble and some insoluble in water. If any of the former exist in soils therefore, they will be dissolved, if the soil be boiled in water. And if afterwards this water be evaporated, the salt can be obtained in a dry state and weighed. This is the way in which column seventh was filled. Tests were also applied to the solutions, in order to ascertain the nature of these salts. Hydrocyanate of potassa, infusion of nutgalls, the chlorides of calcium and magnesium, and the carbonate of ammonia and phosphote of soda gave no precipitate in any instance. Hence I infer the absence of iron and the salts of magnesia. But nitrate of silver, baryta water, nitrate and acetate of baryta, and oxalate of ammonia, gave precipitates more or less abundant in every instance in which I tried them. I hence infer the presence of a sulphate, probably the sulphate of lime, in all

the soils of Massachusetts that I have examined, and I have no doubt but it exists in every one of our soils. The quantity given in the table, is probably much less than the truth, for the sulphate of lime is but slightly soluble in water, and the quantity of water which I employed, was too small to dissolve all that exists in 100 grains; or rather 200 grains, which was the quantity usually boiled. It was chiefly to ascertain the fact of its existence that the experiments were performed; since I had adopted a better method for ascertaining its quantity. This salt exists, also, probably in nearly all the springs, rivers, and ponds in the State. The great importance of gypsum, in the process of vegetation, furnishes a reason for its universal diffusion.

The remaining columns of the Table exhibit the composition of the aluminous deposite in the sixth column. That deposite was boiled two or three hours in sulphuric, or hydrochloric acid, and the alumina and iron were precipitated together by carbonate of ammonia, and afterwards separated by hydrate of potassa. The portion remaining undissolved by the acid, was considered as silica.

Insufficiency of this mode of Analysis.

I might easily have proceeded farther with these analyses: but had I at the commencement the same opinion of the insufficiency of Davy's method, as I now have, I should not have proceeded even so far. So far as this method is mechanical, it is of value; since it enables any one, not skilled in the manipulations of the laboratory, to ascertain whether a soil is coarse, or in a finely divided state. But the chemistry of this method is very bad. In the first place, it does not profess to determine the amount of silica, alumina, iron, &c. in the entire soil, but only in its finely divided portion. Now I have already mentioned a case, in which the siliceous residuum (of No. 23.) yielded almost as large a per cent. of alumina and oxide of iron as the aluminous portion. And I shall soon mention numerous examples, in which accurate analysis of the whole soil shows a much larger per cent. of these ingredients than this method discovers. In the second place, this method does by no means give the relative proportion of the ingredients in a soil, especially of the silica and alumina; because the latter is soluble with difficulty in sulphuric acid. Being desirous of ascertaining what proportion of the alumina could be extracted by the direct action of acids, I selected seven of the soils given in the preceding table, and subjected the aluminous deposite, obtained in the manner that has been described, to thorough analysis by fusion with soda, in platinum crucibles. The results may be seen in the following Table.

No.	Aluminous Deposite.	Alumina by Acids.	Alumina by Alkali.	Silica by Acids.	Silica by Alkali.	Alumina per cent.	
2	58.5	3.4	17.6	51.0	37.5	30.1	
40	44.0	8.0	11.8	27.5	23.7	26.8	
41	28.1	3.1	9.4	23.1	16.8	33.6	
47	19.5	3.5	6.3	13.5	10.7	32.3	30.9 Mean.
58	42.3	5.8	12.2	32.3	25.9	28.8	
89	49.0	6.7	14.9	38.9	30.7	30.4	
112	39.3	5.1	13.0	31.3	23.0	34.3	

The number of the soil in the state collection* is given in the first column of the above table: the amount of the aluminous deposite in the second; the alumina by boiling in acid, as given in the first table, in the third column; the alumina by fusion with carbonate of soda in the fourth column: the silica, after the action of acids, in the fifth: the silica by alkali in the sixth: and the per cent. of alumina by the same process in the last.

A mere glance at these results, if they are not very erroneous, shows us how extremely deficient are Davy's rules in this particular. It is true that a repetition of his process, with fresh sulphuric acid, would dissolve more alumina; and in this way a gradual approximation might be obtained towards the truth: but such repetitions would prove more laborious than the process by fusion with alkali, and thus defeat the very object this distinguished chemist had in view, viz. so to simplify the analysis of soils, that it might be performed by intelligent farmers, though not familiar with chemical manipulation.

But in the third place, I have been brought to the conclusion, that even if these rules should give accurately the proportion of the ingredients, they would be of little importance; because the fertility of soils depends but very little upon the proportion of their earthy ingredients: in other words, these may vary greatly, without affecting the fertility. Partly to ascertain how far this principle is true, and partly to determine more accurately what are the earthy constituents of the soils of Massachusetts, I have made several analyses of the different geological varieties by fusion with an alkali; the only method which can at all satisfy the chemist. In the first example no attempt was made to determine the presence or amount of lime and magnesia. 100 grains of a diluvial argillaceous soil from Plymouth contain,

* There are two series of numbers in the State Collection both commencing with unity. One series is confined entirely to those specimens that are contained in glass bottles, which amount to 227. The other series extends to more than 2500. To distinguish between the two series, whenever they are referred to, I shall annex the letter *b*, to those of the first series, except the soils, which amount to 152, and the marls, clays, marly clays, and muck sands, where it seems unnecessary.

Water of Absorption.	2.7
Organic Matter.	6.0
Oxide of Iron.	6.5
Salts Soluble in Water.	0.4
Alumina.	19.2
Silica.	65.2
	100.0

In the following examples, I directed my attention to a determination of the amount of silica, alumina, lime, and magnesia, in the entire soil; having previously driven off the water and organic matter by heat. The salts of lime were obtained by another process, which will be explained farther on; and are added here for the sake of giving a complete view of the composition of the soils. It will be seen that I have added, for the sake of comparison, four examples of some of the richest soils in Illinois and Ohio. For convenience, the results are reduced to a centessimal standard: although only 15 grains were usually employed in the analysis.

NO.	LOCALITY.	Water of Absorption.	Organic Matter.	Silica.	Alumina.	Peroxide of Iron.	Carbonate of Lime.	Sulphate of Lime.	Phospate of Lime.	Lime.	Magnesia.	Loss.
1	Alluvial Soil, Deerfie d.	2.0	7.0	55.50	22.06	5.11		2.00	0.90	2.18	2.00	1.23
18	Diluvial Sand, Wareham.	1.4	1.2	84 68	7.76	1.89		0 40	0.40	2.32		
23	Red Sandstone Soil, L.Meadow	4.2	3.6	65.45	16.45	5.07		3.20	0.60	0.74	0.25	0.44
28	Graywacke Soil, Roxbury.	2 6	8.4	63 68	17.37	3.65		2.30	1.46		0.48	0 12
41	Argil. Slate Soil, Lancaster.	7.4	7.4	57.87	16.06	4.70		4 60	0.90	0.59	0.44	0.04
46	Limestone Soil, G. Barrington.	2.0	6.0	69.52	12.22	5.03		1.70	0.50	1.14	0.76	0.73
59	Mica Slate Soil, W. Newbury.	3.8	5.8	67 49	11 87	3.80		3 50	1.00	1.09	1.08	0.57
64	Talcose Slate Soil, Chester.	2 6	4.6	68.01	14.10	2.57		3.10	1.00		2.82	1.20
81	Gneiss Soil, Petersham.	5.6	7.4	60 85	18 77	3.22		2.40	0.40		1.14	0.22
103	Granite Soil, Duxbury.	2 4	5.2	74 77	12.57	3.10		0 80	0.70	0.11	0.07	0.28
109	Sienite Soil, Lexington.	4.0	9.8	65.00	13.11	4 00		2.60	0.60		0.52	0 37
120	Porphyry Soil, Medford.	2 8	12.4	59.78	16.38	3.54		2.60	0.80	0 81	0.80	0.09
125	Greenstone Soil, Deerfield.	2 0	6 2	65.39	16 35	6.05	2.00	0.10	0.30	0.63	0.91	0.07
198	Rushville, Illinois.	6 3	9.9	63 35	15.00	5.57	1.50	3.40	0.60		0.68	
199	Sangamon Co. do.	6.3	10.5	66 71	8.28	4.42	1.30	1.20	0.40		0.56	0.33
200	Lazelle Co. do.	9 5	21.4	47.09	9.87	5.38	3.30	1.40	0.40		1.08	0.58
201	Sciota Valley, Ohio.	5.3	11.2	62.64	9.18	5.40	2.80	2.10	0 90		trace	0.48

The preceding Table hardly needs explanation: except to remark, that the column headed Lime, contains the excess of that substance, found by the process with alkali in some specimens, above the amount contained in the carbonate, sulphate, and phosphate. This excess probably existed in the soil either as a silicate or a geate.

For the sake of a more extensive comparison, I shall here quote a few analyses of soils that have been distinguished for their fertility. Most of them are European.

In the Second Report of Mr. Colman on the Agriculture of Massachusetts, Dr. S. L. Dana has given the analysis of a soil from Chelmsford, on the Merrimack River, which has produced a large crop of wheat for 20 years with only one failure. 100 parts contain

Soluble Geine,	3.9228
Insoluble Geine,	2.6142
Sulphate of Lime,	.7060
Phosphate of Lime,	.9082
Silicates (Silica, alumina, iron, &c.)	91.8485

No trace of carbonate of lime or of alkaline salts could be discovered.

In his third annual report on the geology of Maine, Dr. C. T. Jackson has given the following analysis of a soil from that State, which has produced 48 bushels of wheat per acre.

Water,	5.0
Vegetable Matter,	17.5
Silica,	54.2
Alumina,	10.6
Sub Phosphate of Alumina,	3.0
Peroxide of Iron,	7.0
Oxide of Manganese,	1.0
Carbonate of Lime,	1.5
	99.8

An excellent wheat soil from the County of Middlesex in England, was analyzed by Sir Humphry Davy, and gave in 100 parts,

Siliceous Sand,	60
Finely divided matter,	40

100 parts of the latter gave

Carbonate of Lime,	28
Silica,	32
Alumina,	29
Organic Matter and Water,	11

A very productive soil from the County of Somerset, gave

Siliceous Sand,	89
Finely divided Matter,	11

432 parts of the latter gave

Carbonate of Lime,	360
Alumina,	25
Silica,	20
Oxide of Iron,	8
Organic and Saline Matter,	19

Bergman found one of the most fertile soils in Sweden to contain

Coarse Silica (sand,)	30
Silica,	26
Alumina,	14
Carbonate of Lime,	30

Giobert found the following to be the composition of one of the most fertile soils in the neighborhood of Turin.

Silica,	77 to 79
Alumina,	9 to 14
Carbonate of Lime,	5 to 12

A very fertile soil in France gave, according to the analysis of Chaptal,

Siliceous Gravel,	32
Calcareous Gravel,	11
Silica,	10
Alumina,	21
Carbonate of Lime,	19
Organic Matter,	7

The most fertile mixture obtained by Tillet, in numerous experiments made at Paris, contained the following ingredients.

Coarse Silica (Sand,)	25.0
Silica,	21.0
Alumina,	16.5
Carbonate of Lime.	37.5

(Chaptal's Chemistry applied to Agriculture, p. 25. first Boston Edition.)

Inferences.

Though the analyses quoted above are referred to different standards, yet it is easy to see that the earthy ingredients are exceedingly various, if we look only to the most fertile soils. In one, that from Somerset in England, siliceous sand and carbonate of lime constitute 98 per cent. of the soil; while alumina is less than one per cent. In most of those from Massachusetts, there is no carbonate of lime, and only one or two per cent. of lime in any combination. The prairie soils of the Western States, confessedly among the most fertile on the globe, appear to contain a larger proportion of silica and a less proportion of alumina, than almost any variety of soil from Massachusetts. Upon the whole, the facts stated above, taken in connection with settled principles in Agricultural Chemistry, will warrant the following inferences.

1. A soil composed wholly or chiefly of one kind of earth will not produce any healthy vegetation. If nineteen twentieths be silica, or alumina, lime, or magnesia, it is said that it will be barren. On this account

the numerous sand hills or dunes in the southeastern part of Massachusetts, are almost entirely barren; and it appears from the first table of analysis which I have given, that these sands contain less than one twentieth of finely divided matter. In England however, a writer on this subject (*Rees Cyclopedia, Article, Soil,*) say sthat he has seen a tolerable crop of turnips on a soil containing eleven out of twelve parts of sand. Any one may also see in Plymouth and Barnstable counties in the summer, very good crops of wheat on land similar to that analysed from Wareham, which contains 85 per cent. of silica.

2. Though plants may be made to grow in soils composed of only two sorts of earths, yet in order to render them very fertile, it is necessary that they should contain at least silica, alumina, and lime; and probably also iron and magnesia are important. That these ingredients are wanted by most plants is evident from their analysis: although we are not perhaps warranted in saying that they are all indispensable to a tolerably healthy development of the plant. 100 parts of the ashes of the following plants were found to contain as follows:

Ashes of wheat,	48 Silica,	37 Lime.	15 Alumina.
" of oats,	68 "	26 "	6 "
" of barley,	69 "	16 "	15 "
" of rye,	63 "	21 "	16 "
" of potatoes,	4 "	66 "	30 "
" of red clover,	37 "	33 "	30 "

Most plants also contain several salts soluble in water: also earthy phosphates, and carbonates and metallic oxides: as may be seen by consulting Chaptal's Chemistry applied to Agriculture, p. 176. Now if those ingredients be not furnished by the soil, from whence can the plants obtain them?

3. Only a small quantity of earthy ingredients is required for plants; and hence the proportions in which they exist in the soils may vary exceedingly without affecting their fertility, so far as the food of the plant is concerned.

4. The degree of comminution or fineness in a soil, is of far more importance in its bearing upon fertility, than its chemical composition, so far as the earthy ingredients are concerned. The power of a soil to absorb and retain moisture, as well as the power of the rootlets of plants, to take up nourishment from the soil, depend in a great measure upon its fineness. If the particles be too coarse to accomplish these objects, it can be of little consequence whether those particles are pure silica, or alumina, or lime, or iron, or a mixture of the whole. And if they be fine enough, I do not see why one kind may not answer nearly as well as another, provided enough of them all be present to enter into the composition of the plants: though doubtless al-

umina of the same fineness would be of a closer texture and absorb more moisture, than the others. The soils of New England are usually regarded as too siliceous: and yet, from the preceding table it seems they are less so than the rich prairie soils of the western states. But these western soils are reduced almost to an impalpable powder, more fine than even any of the alluvium of Massachusetts that I have seen: and I apprehend that this is a principal cause of their fertility.

5. Hence we infer, that in some instances, one earthy ingredient may be substituted for another. In a letter from A. A. Hayes Esq. of Roxbury, whose opinion on this subject cannot but be highly appreciated, he says, "The process of absorption and retention may be so much modified by comminution, that I think a silico-ferruginous soil may assume the characters of an alumnious soil to a certain extent; and that the existence of a due proportion of finely divided matter is of more consequence than is its composition." In this view of the subject, the mechanical part of Davy's rules for the analysis of soils, becomes of more importance than the chemical part. And the mechanical part, that is, the determination of the quantity of finely divided matter, can be performed by every farmer of tolerable ingenuity with a very few articles of apparatus.

6. It appears that to spend much time in an accurate chemical determination of the earthy constituents of soils, is of little importance. If there was any one definite compound of the earths which would always give the maximum of fertility, such analyses would be important: but I have shown, if I mistake not, that great diversity in this respect is consistent with the highest amount of fertility. Or if it should prove true, as I confidently think it will not, that there is a particular proportion of earthy ingredients most favorable to fertility, as Tillet undertook to show in respect to Paris, I apprehend that the same proportion will not produce the maximum of fertility in countries where the temperature and the amount of rain are different.

There is one respect, however, in which this kind of analysis may be of service in a region like New England, where lime exists in the soil in such small proportion; and that is, to determine whether it exists at all. There is another method, however, of ascertaining the presence of the most important salts of lime in a soil, which I shall explain shortly, and which is more easy than analysis in the dry way by alkali.

The fact is, every farmer is acquainted with the difference between sandy, clayey, and loamy soils; and it is doubtful whether the most delicate analysis will afford him much assistance of much practical value in respect to these distinctions.

I could easily have analyzed all the soils which I have collected in the

manner that has been described. But for the reasons above given, and because a new mode of analysis of greater value was unexpectedly brought to my notice, I have judged it inexpedient to proceed. I wish however to say, that in thus giving my opinion of the entire inadequacy of most of the steps in Davy's rules for the analysis of soils, I do not mean to intimate that it is owing to any want of skill in that distinguished chemist: but simply because he attempted an impossibility, viz. to frame popular rules for such analyses as can be performed only by the experienced chemist and with the best apparatus and ingredients.

7. Finally, if these positions be correct, then it follows that almost every variety of soil may by cultivation be rendered fertile. If we can only be certain that silica, alumina, and lime, are present, we need not fear, but by those modes of cultivation which every enlightened farmer knows how to employ, it may be made very productive. In nearly all the soils in Massachusetts, for instance, the only question will be respecting the presence of lime; since he may be sure the other constituents are present. It is not necessary, therefore, for our young men to go to distant regions in search of fertile soils. Patient industry will ensure them such soils within their own borders: and the same may be said of nearly every country: a fact which strikingly exhibits the Divine Beneficence.

Analysis for determining the salts and organic matter of Soils.

With the exception of carbonate of lime, which I have regarded as one of the earthy ingredients of soils, although it is properly a salt, the amount of organic matter in a soil cannot be greatly diminished, nor that of salts greatly increased, without rendering it sterile. And yet, the existence of both salts and organic matter seems essential to successful cultivation. It hence becomes a matter of no little importance, to ascertain the existence and amount of these substances in soils. This it is true, can be done by the modes of analysis already described: But in respect to some important salts, especially the phosphates, it is well known that their detection by the ordinary modes of analysis is very difficult. And in respect to the organic matter, the method hitherto proposed by Davy, Chaptal, and others, simply ascertains its amount by burning it off. Now it is well known that a field may abound in organic matter, as for instance a peaty soil, and yet be entirely barren. Another field may contain but little organic matter, and yet be very productive; though soon exhausted. The same quantity of manure on one field, will render it productive much longer than another field. On one field it is rapidly dissipated: on another, it is fixed, or so combined as to be permanent. Hence it is of greater importance to determine what

is the condition of organic matter in a soil, than its amount. It seems to be well ascertained, that in order to its being taken up by the rootlets of plants, it must be in a state of solution; and in order to prevent its being dissipated, it must be chemically combined with some of the earthy ingredients of the soil. But these matters have hitherto been scarcely touched in the rules given for analysis. This desideratum, however, has in my opinion been in a good measure supplied by a chemical friend, and will be described in the sequel.

Examination for Carbonate of Lime.

Many of the analyses of European soils, represent them as containing a rather large per centage of carbonate of lime: and hence it was natural to expect a similar constitution in the soils of this country. But the result is different from the anticipation. In order to determine this point, I adopted the following method. A small quantity of the soil was introduced into a watch glass, so placed that the light from a window would fall upon it. This soil was coverd with water to a considerble depth. The soil was then stirred until the light matter and every bubble of air had risen to the top. The impurity that floated on the surface was then removed by drawing over it a piece of bibulous paper, so that the water stood perfectly clear above the soil. Then a few drops of muriatic acid were added by a dropping tube and the water was carefully watched to see if any bubbles rose through it, as they would have done if any carbonate were present. The minutest quantity of gas escaping, could in this manner be perceived.

I am confident that if in 100 grains of the soil, (the quantity usually employed) the fiftieth part of a grain had existed, it might in this manner have been detected. The result disclosed the remarkable fact, that out of 145 soils examined from all parts of the state, and some of them underlaid by limestone, only 14 exhibited any effervescence; and even these, when analyzed, yielded but a small per centage of carbonate of lime: viz.

No. 176	Alluvial Soil, Westfield,		6.2	per cent.
" 180	Sandy Soil, Truro,		21.3	"
" 35	Graywacke Soil, Watertown,		1.30	"
" 51	Limestone Soil, Sheffield,		0.80	"
" 52	do	West Stockbridge,	3.20	"
" 192	do	Saddle Mountain Adams,	1.50	"
" 189	do	Richmond,	0.80	"
" 183	Argillaceous Slate Soil, Boston Corner,		2.98	"
" 196	Talcose Slate Soil, Mount Washington,		2.77	"
" 78	Gneiss Soil, Westminster,		3.00	"

"	80	Gneiss Soil	Fitchburg,	2.10	per cent.
"	186	do	Sandisfield,	2.80	"
"	113	Sienite Soil,	Wrentham,	0.40	"
"	125	Greenstone Soil,	Deerfield,	2.00.	"

Even in several of the above instances I am convinced that the calcareous matter was not natural to the soil. Thus, I afterwards learnt that the field in Westfield, (about a mile west of the village,) from which the above specimen was taken, had been highly manured; and having collected another specimen in an adjoining field, I could detect no carbonate in it. Nos. 31, 78, 80, and 125 also, contrary to my usual custom, were obtained in small patches of cultivated ground near villages; and most probably these had been highly manured if not with lime yet with substances that might produce a carbonate of some sort. And No. 180 was full of fragments of sea shells. Setting aside these specimens, we find that only one in 10 of our soils contains any carbonate of lime; and if we leave out of the account, the soils from the limestone region of Berkshire, we may consider nearly every other soil in the state as destitute of that substance. Even in Berkshire, it is rare to meet with soils that effervesce; and I have found none there, that contained but a very small proportion of the carbonate of lime. From the able work of Edmund Ruffin Esq. of Virginia, on calcareous manures, it appears that the same is true of the soils of that state: and also of some of the western states; even where limestone is the prevailing rock. The analyses of western soils, also, which I have given, show but a small proportion of this ingredient. Upon the whole, I think we may fairly infer that the soils in general in this country are less charged with carbonate of lime than those of Europe. In the primitive parts of our country, such as New England, this is easily explained, from the great dearth of limestone. In other parts, perhaps the fact may be explained by the powerful effects of diluvial action, and the more compact nature of our limestone in our vast secondary deposites, whereby they are less liable to disintegration, than many of those in Europe. Or not improbably, the great amount of vegetation, that has for thousands of years spread over our country, while it has added to the organic matter of the soil, may have used up much of the carbonate of lime: For that the growth of vegetables will gradually consume the calcareous matter of the soil, seems now pretty well established.

New Method of analyzing Soils.

Without stopping to suggest any means for supplying the deficiencies which the preceding analyses have shown in our soils, I proceed to the de-

velopment of a new method of analysis, which I very unexpectedly received from a distinguished chemical friend, and which he has allowed me to present in this Report, with its application to our soils. It is the invention of Dr. Samuel L. Dana of Lowell, to whom, as will appear in the sequel, I am indebted for other important assistance in the way of analysis. In order to its being fully understood and appreciated, a few preliminary statements from myself, in addition to those by Dr. Dana, will be necessary.

Till within a few years past, the state in which vegetable and animal matter exists in the soil, and the changes through which it passes, before being taken up by the roots of the plant, were almost entirely unknown to chemists. Long ago, however, Klaproth had discovered a peculiar substance in the elm tree, which he denominated *ulmin.* More recently it was found by Braconnot in starch, saw-dust, and sugar; and by the distinguished Swedish chemist, Berzelius, in all kinds of barks. Sprengel, and Polydore Boullay have ascertained, also, that it constitutes a leading principle in manures and soils. Hence they call it *Humin*; but Berzelius adopts the name of *Geine.* When wet, it is a gelatinous mass, which, on drying, becomes of a deep brown or almost black color, without taste or smell, and insoluble in water; and, therefore, in this state incapable of being absorbed by the roots of plants. Yet after the action of alkalies upon it, it assumes the character of an acid, and unites with ammonia, potassa, lime, alumina, &c., and forms a class of bodies called *Geates,* most of which are soluble in water, and therefore capable of being taken up by plants. And it is in the state of geates, that this substance for the most part exists in the soil. I have thought it might at least gratify curiosity, and perhaps be of some practical use, to add specimens of these forms of geine to the collection of soils. No. 227 is pure geine: No. 226 geate of potassa: No. 225 geate of lime: No. 224 geate of alumina.

It is but justice to say, that Dr. Dana derived his knowledge of geine chiefly from his own researches, made with a view to improve the coloring processes in the Calico Printing Establishment, at Lowell: and his method of analyzing soils is altogether original. The statements of Berzelius, indeed, though interesting in a theoretical point of view, afford very little light to the practical agriculturalist. Those of Dr. Dana appear to me to be far more important; although essentially coinciding with those of European chemists. His method of analysis, derived from his researches, I must say, after having made extensive application of it to our soils, is simple and elegant, and taken in connection with his preliminary remarks, it appears to me to be a most important contribution to agricultural chemistry, and promises much for the advancement of practical agriculture. I trust it will be favorably received by the government, and by all intelligent men, who take an interest in the subject. His preliminary remarks and rules I shall now present in his own language.

"By *geine*," says he, "I mean all the decomposed organic matter of the soil. It results chiefly from vegetable decomposition; animal substances produce a similar compound containing azote. There may be undecomposed vegetable fibre so minutely divided as to pass through the sieve; (see first step in the rules for analysis) but as one object of this operation is to free the soil from vegetable fibre, the portion will be quite inconsiderable It can affect only the amount of insoluble geine. When so minutely divided, it will probably pass into geine in a season's cultivation. Geine exists in two states: soluble and insoluble: soluble both in water and in alkali, in alcohol and acids. The immediate result of recent decomposition of vegetable fibre is abundantly soluble in water. It is what is called Solution of Vegetable Extract. Air converts this soluble into *solid* geine, *still partially soluble in water*, wholly soluble in alkali. Insoluble geine is the result of the decomposition of solid geine: but this insoluble geine, by the long continued action of air and moisture, is again so altered as to become soluble. It is speedily converted by the action of lime into soluble geine. Soluble geine acts neither as acid nor alkali. *It is converted into a substance having acid properties by the action of alkali;* and in this state combines with earths, alkalies, and oxides, forming neutral salts, which may be termed *geates.* These all are more soluble in water than solid geine; especially when they are first formed. Their solubility in cold water is as follows: beginning with the easiest: magnesia—lime—manganese—peroxide of iron—(it does not unite with the protoxide of iron) alumina—baryta. The geates of the alkaline earths are decomposed by carbonated alkali. The geates of alumina and of metallic oxides are soluble in caustic or carbonated alkali without decomposition. The geates of the alkaline earths, by the action of the carbonic acid of the air, become *super-geates,* always more soluble than neutral salts. Soluble geine, therefore, includes the watery solution—the solid extract caused by the action of air on the solution, and the combinations of this with alkalies, earths, and oxides. Insoluble geine includes all the other forms of this substance."

"Soluble geine is the food of plants. Insoluble geine becomes food by air and moisture. Hence the reason and result of tillage. Hence the reason of employing pearlash to separate soluble and insoluble geine in analysis."

"These are the facts. Will they not lead us to a rational account of the use of lime, clay, ashes and spent ley? Will they not account for the superiority of unfermented over fermented dung in some cases?"

Dr. Dana's remarks in answer to these inquiries I shall omit for the present, and quote the remainder of his remarks preliminary to his rules for analysis. If any sentences seem to be somewhat repetitious of those alrea-

dy quoted, it is sufficient to say, that they were communicated at different times, in private letters, in answer to inquiries which I had made, that I might be sure not to mistake his meaning. On a subject so new, some repetitions are not undesirable.

"Geine forms the basis of all the nourishing part of all vegetable manures. The relations of soils to heat and moisture depend chiefly on geine. It is in fact, under its three states of 'vegetable extract, geine, and carbonaceous mould,' the principle which gives fertility to soils long after the action of common manures has ceased. In these three states it is essentially the same. The experiments of Saussure have lòng ago proved that air and moisture convert insoluble into soluble geine. Of all the problems to be solved by agricultural chemistry, none is of so great practical importance as the determination of the quantity of the soluble and insoluble geine in soils. This is a question of much higher importance than the nature and proportions of the earthy constituents and soluble salts of soils. It lies at the foundation of all successful cultivation. Its importance has been not so much overlooked as undervalued. Hence, on this point the least light has been reflected from the labors of Davy and Chaptal. It needs but a glance at any analysis of soils, published in the books, to see that fertility depends not on the proportion of the earthy ingredients. Among the few facts, best established in chemical agriculture, are these: that a soil, whose earthy part is composed wholly or chiefly, of one earth; or any soil, with excess of salt, is always barren; and that plants grow equally well in all soils, destitute of *geine*, up to the period of fructification:—failing of geine, the fruit fails, the plants die. Earths, and salts, and geine, constitute, then, all that is essential; and soils will be fertile, in proportion as the last is mixed with the first. The earths are the plates, the salts the seasoning, the geine the food of plants. The salts can be varied but very little in their proportions, without injury. The earths admit of wide variety in their nature and proportions. I would resolve all into "*silicates*;" by which I mean the finely divided, almost impalpable mixture of the detritus of granite, gneiss, mica slate, sienite, and argillite; the last, giving by analysis, a compound very similar to the former. When we look at the analysis of vegetables, we find these inorganic principles constant constituents—silica, lime, magnesia, oxide of iron, potash, soda, and sulphuric and phosphoric acids. Hence these will be found constituents of all soils. The phosphates have been overlooked from the known difficulty of detecting phosphoric acid. Phosphate of lime is so easily soluble when combined with mucilage or gelatine, that it is among the first principles of soils exhausted. Doubtless the good effects, the lasting effects, of bone manure, depend more on the phosphate of lime, than on its animal portion. Though the same plants growing in different soils are

found to yield variable quantities of the *salts* and earthy compounds, yet I believe, that accurate analysis will show, that similar parts of the same species, at the same age, always contain the inorganic principles above named, when grown in soils arising from the natural decomposition of granitic rocks. These inorganic substances will be found not only in constant quantity, but always in definite proportion to the vegetable portion of each plant. The effect of cultivation may depend, therefore, much more on the introduction of *salts* than has been generally supposed. The *salts* introduce new breeds. So long as the salts and earths exist in the soil, so long will they form voltaic batteries with the roots of growing plants; by which, the silicates are decomposed and the nascent earths, in this state readily soluble, are taken up by the absorbents of the roots, always a living, never a mechanical operation. Hence so long as the soil is chiefly *silicates,* using the term as above defined, so long is it as good as on the day of its deposition; *salts* and *geine* may vary, and must be modified by cultivation. The universal diffusion of granitic diluvium will always afford enough of the earthy ingredients. The fertile character of soils, I presume, will not be found dependent on any particular rock formation on which it reposes. Modified they may be, to a certain extent, by peculiar formations; but all our granitic rocks afford, when decomposed, all those inorganic principles which plants demand. This is so true, that on this point the farmer already knows all that chemistry can teach him. Clay and sand, every one knows: a soil too sandy, or too clayey, may be modified by mixture; but the best possible mixture does not give fertility. That depends on salts and geine. If these views are correct, the few properties of geine which I have mentioned, will lead us at once to a simple and accurate mode of analyzing soils,—a mode, which determines at once the value of a soil, from its quantity of soluble and insoluble vegetable nutriment,—a mode, requiring no array of apparatus, nor delicate experimental tact,—one, which the country gentleman may apply with very great accuracy; and, with a little modification, perfectly within the reach of any man who can drive a team or hold a plough."

Rules of Analysis.

1. "Sift the soil through a fine sieve. Take the fine part; *bake* it just up to browning paper."

2. "Boil 100 grains of the baked soil, with 50 grains of pearl ashes, saleratus, or carbonate of soda, in 4 ounces of water, for half an hour; let it settle; decant the clear: wash the grounds with 4 ounces boiling water: throw all on a double weighed filter, previously dried at the same temperature as was the soil (1); wash till colorless water returns. Mix all these liquors. It is a

brown colored solution of all the soluble geine. All sulphates have been converted into carbonates, and with any phosphates, are on the filter. Dry therefore, that, with its contents, at the same heat as before. Weigh—the loss is *soluble geine.*"

3. "If you wish to examine the geine; precipitate the alkaline solution with excess of lime-water. The *geate* of lime will rapidly subside, and if lime-water enough has been added, the natant liquor will be colorless. Collect the geate of lime on a filter: wash with a little acetic or very dilute muriatic acid, and you have geine quite pure. Dry and weigh. Deduct the weight from the soluble geine, (rule 1.) the remainder is the amount of alumina, oxide of iron, magnesia, sulphuric and phosphoric acids contained in the alkaline solution."

4. "Replace on a funnel the filter (2) and its earthy contents: wash with 2 drams muriatic acid, diluted with three times its bulk of cold water. Wash till tasteless. The carbonate and phosphate of lime will be dissolved with a little iron, which has resulted from the decomposition of any salts of iron, beside a little oxide of iron. The alumina will be scarcely touched. We may estimate all as *salts* of lime. Evaporate the muriatic solution to dryness, weigh and dissolve in boiling water. The insoluble will be *phosphate of lime.* Weigh—the loss is the *sulphate of lime;* (I make no allowance here for the difference in atomic weights of the acids, as the result is of no consequence in this analysis.)"

5. "The earthy residuum, if of a greyish white color, contains no insoluble geine—test it by burning a weighed small quantity on a hot shovel—if the odor of burning peat is given off, the presence of insoluble geine is indicated. If so, *calcine* the earthy residuum and its filter—the loss of weight will give the insoluble geine; that part which air and moisture, time and lime, will convert into soluble vegetable food. Any error here will be due to the loss of water in a hydrate, if one be present: but hydrates exist in too small quantities in soils to affect the result. The actual weight of the residuary mass shows the amount of *Silicates* in the soil.

"The clay, mica, quartz, &c. are easily distinguished. If your soil is calcareous, which may be easily tested by acids; then before proceeding to this analysis, boil 100 grains in a pint of water, filter and dry as before: the loss of weight is due to the *sulphate of lime:* even the sulphate of iron may be so considered: for the ultimate result in cultivation is to convert this into sulphate of lime."

"Treat the soil with muriatic acid, and having thus removed the lime, proceed as before, to determine the geine and insoluble vegetable matter."

As soon as made acquainted with this mode of analysis, it appeared to me so much more important and accurate than any other with which I was conver-

sant, that I felt determined, if possible, to apply it to the soils of Massachusetts; and by extra efforts, I have the pleasure of presenting in the following table the results of its application to all our soils which I have collected, viz. 146: and I shall show hereafter, similar results with our marls, clays, and other substances, to which this method can be applied.

No.	NAME AND LOCALITY OF THE SOIL.	Soluble Geine.	Insoluble Geine.	Sulphate of Lime.	Carbonate of Lime.	Phosphates.	Silicates.	100 grains heated to 300° F. absorbed in 24 hours.	Absorbing Power in Proportional Numbers.	Specific Gravity.
1	Alluvium—Deerfield,	3.5	1·2	2.0		0.9	92.4	3.3	65	2·44
2	do Northampton,	2.8	4.2	2.4		1.0	89.6	2.0	40	2 45
3	do Deerfield,	2.3	1.1	1.6		0.9	94.1	2.1	42	2.58
4	do Northampton,	1.2	2.4	0.9		1.1	94.4	1.2	25	2.68
5	do Northfield,	2.8	2.8	1.5		0.6	92.3	2.9	58	2.55
6	do Northampton,	2.4	0.8	2.8		0.8	93.2	1.4	28	2.55
7	do W. Springfield,	3.2	1·2	1.3		0.7	93.6	3.0	60	2.46
176	Alluvium—Westfield,	2.4	2.7	2.6	6.2	1.0	85.1			2.38
177	do do (an adjoining field,)	1.5	1.2	0.9		0.3	96.1			
8	do Stockbridge,	3.3	0.8	2.9		0.5	92.5	1 9	38	2.55
9	do Hadley,	2.5	2.3	2.7		1.0	91.5	5.0	100	2.46
10	do Sheffield,	1.3	5.2	1.7		0.5	91.3	3.5	70	2.53
11	do Deerfield,	2.5	2.4	0.8		0.8	93.5	2.0	40	2.58
12	do W. Springfield,	1.5	1.5	1.0		0.5	95.5	1.5	30	2.65
13	Diluvial Argillaceous—Springfield,	4.8	5.8	2.4		1.2	85.8	6.3	126	2.31
14	do do Northampton,	4.8	4.6	1.6		0.8	88.2	6.1	122	2.37
15	do do Plymouth,	2.9	4.9	1.8		0.9	89.5	4.9	98	2.34
16	do do Barnstable,	4.4	5.9	0.9		0.6	88.2	4.9	98	2.39
17	do do Sandwich,	2.8	4.9	3.0		1.1	88.2	4.2	84	2.37
18	do Sandy—Wareham,	0.5	0.0	0.4		0.4	98.7	0.5	10	2.37
19	do do Springfield,	3.2	0.0	1.6		0.6	94.6	1.7	34	2 60
168	do do uncultivated, Northampton,	3.6	4.4	0.5		0.5	91.0			
179	do Loamy—Amherst,	3.5	2.3	2.5		0.9	90.8			2.37
178	do Sandy—Sheffield,	0.0	0.8	03.2		0.08	98.8			2.66
180	do do Truro,*	3.7	1.6		21.3	0.35	73.1	1.7	34	
20	do do Barnstable,	0.0	0.0	0.1		0.3	99.6	0.8	16	2.72
21	do do Gloucester,						100.	0.7	14	2.71
22	Sandstone, (Red,)—Deerfield.	0.3	2.6	0.8		0.7	95.6	3.4	68	2.53
23	Sandstone, (Red,)—Longmeadow,	3.2	0.5	3 2		0.6	92.5	3.2	64	2.43
24	do do Wilbraham,	6.1	2.0	1.0		0.8	90.1	2.5	50	2.60
25	do do W. Springfield,	4.1	3.8	4.3		0.7	88.1	2.7	54	2.46
26	do (Gray,)—Granby,	2.7	1 8	0.6		0.8	94.1	3.0	60	2.51
27	Graywacke Soil—Dorchester,	7.6	2.1	1.8		1.0	87.5	4.5	90	2.37
28	do Roxbury,	4.4	3.8	2.3		1.4	88.1	3.9	78	2.43
29	do Brookline,	6.0	5.3	3.1		1.4	84.2	5.8	116	2.34
30	do Walpole,	2.6	5.5	1.9		0.8	89.2	3.1	62	2.31
31	do Dighton,	2.1	3 4	1.9		0.5	92.1	1.5	30	2.34
32	do Middleborough,	1.2	3·7	2.1		0.9	92.1	1.6	32	2.48
33	do Quincy,	2.1	5.0	2.4		1.5	90.0	3.5	70	2.44
34	do W. Bridgewater,	3.4	2.3	1.2		0.6	92.5	2.5	50	2.40
35	do Watertown,	5.6	5 5	1.9	1.3	1.1	84.6	4.6	92	2.27
36	do Halifax,	3.3	2.7	0.3		0.8	92.9	1.0	20	2.45
37	do Cambridge,	2.8	3.5	1.8		0.2	91.7	2.6	52	2.45
38	do Taunton,	4.7	2.4	1.8		0.8	90.3	1.8	36	2.44
39	do Attleborough, east part,	2.0	4.1	0.5		0.6	92.8	2.8	56	2.48
40	do do west part,	2.5	6.6	1 9		2.0	87.0	3.7	74	2.21
41	Argillaceous Slate—Lancaster,	5.0	4.5	4.6		0.9	85.0	5.6	112	2.25
42	do Sterling,	6.1	4.6	1.8		0.5	87.0	2.6	52	2.39
43	do Townsend,	6.2	5.0	1.0		1.0	86.8	3.5	70	2.31
184	Argillaceous Slate Soil, uncultivated—Lancaster,	7.9	3.9	2.0		1.0	85.2			
183	do Boston Corner,	4,0	7.3	2.5	3.0	1.0	82.2			2.35
44	Limestone, (Magnesian,)—Marlborough,	4.4	0.5	1.4		2.0	91.7	3.0	60	2.43
45	do Lanesborough,	3.0	0.8	1.1		4.2	90.9	3.6	72	2.39
46	do Great Barrington,	3.6	0.5	1.7		5.0	89.2	3.5	70	2.56
47	do Adams,	2.2	0.4	1.5		3.3	92.6	2.8	56	2.46

* This remarkable soil will receive further notice on a subsequent page.

No.	NAME AND LOCALITY OF THE SOIL.	Soluble Geine.	Insoluble Geine.	Sulphate of Lime.	Carbonate of Lime.	Phosphates.	Silicates.	100 grains heated to 300° F. absorbed in 24 hours.	Absorbing Power in Proportional Numbers.	Specific Gravity.
192	Limestone Soil, Saddle Mt. Adams,	0.7	3.3	0.1	1.5	0.6	93.8			2·58
189	do Richmond,	2.6	2.1	0.8	0.8	0.8	92.9			2.39
190	do South Lee, uncultivated,	2.1	2.3	0.6		0.7	94.3			
191	do Egremont,	1.4	1.5	1.8		0.7	94.6			2.46
48	do Williamstown,	3.1	2.0	2.8		0.6	91.5	5.5	110	2.39
49	do Stockbridge,	2.3	5.2	3.9		0.7	87.9	6.0	120	2.45
50	do Pittsfield,	5.4	5.3	1.0		0.7	87.6	3.0	60	2.39
51	do Sheffield,	2.7	4.2	1.8	0.8	0.5	90.0	5.1	102	2.27
52	do W. Stockbridge,	4.0	5.2	1.0	3.2	1.6	85.0	4.5	90	2.39
53	Mica Slate Soil—West Boylston,	6.0	5.1	0.9		0.6	87.4	4.2	84	2.31
54	do Webster,	5.5	3.1	1.3		1.0	89.1	5.5	110	2.31
55	do Lunenburg,	5.0	3.4	0.8		1.1	89.7	4.3	86	2.29
56	do Stockbridge, Mt.	3.0	5.5	0.2		1.5	89.8	5.3	106	2.40
57	do Chester Village,	6.0	3.5	1.5		1.5	87.5	4.7	64	2.41
58	do Bradford,	6.5	6.8	2.0		1.2	83.5	6.5	130	2.26
59	do West Newbury,	3.0	5.5	3.5		1.0	87.0	4.8	96	2.37
60	do Methuen,	2.9	2.2	1.5		0.6	92.8	0.9	18	2.53
61	do Pepperell,	3.8	7.0	1.6		0.7	86.9	6.2	124	2.27
62	do Norwich,	4.1	4.3	1.2		0.6	89.8	5.3	106	2.36
63	do Conway,	2.0	4.5	1.7		1.1	90.7	3.2	64	2.53
181	do uncultivated Russell,	3.8	6.0	2.7		0.5	87.0			
182	do West Newbury, uncultivated,	5.9	5.7	3.0		0.9	85.5			
64	Talcose Slate Soil—Chester, west part,	1.5	2.1	3.1		1.0	92.3	3.1	62	2,54
65	do Charlemont,	3.8	2.2	1.4		0.6	92.0	3.5	70	2.45
195	do uncultivated Becket,	8.5	4.7	3.7		1.1	82.0			
194	do Rowe,	4.1	4.6	2.5		1.6	87.2			2.35
196	do Mount Washington,	2.6	4.7	1.7	2.0	1.5	87.5			2.33
66	Talco-micaceous Slate—Florida, uncultivated,	3.2	8.4	2.4		2.0	84.0	5.8	116	2.35
67	do Hancock,	6.2	5.8	1.5		1.0	85.5	2.3	46	2.31
68	Gneiss Soil—Tewksbury,	4.3	3.9	1.2		0.8	89.8	3.5	70	2.41
69	do Stow,	4.0	3.0	2.0		1.0	90.0	3.8	76	2.41
70	do Bolton,	4.6	3.4	2.1		0.9	89.0	3.8	76	2.40
71	do Uxbridge,	2.6	3.0	2.9		0.9	90.6	3.5	62	2.36
72	do Mendon,	2.6	2.5	2.4		0.7	91.8	3.4	68	2.51
73	do Tyngsborough,	4.5	1.8	0.6		0.6	92.5	2.6	52	2.45
74	do Holden,	3.9	4.7	1.4		1.4	88.6	5.0	100	2.37
75	do Dudley,	4.0	4.6	1.9		0.7	88.8	5.3	106	2.35
76	do Templeton,	5.2	4.1	2.7		0.5	87.5	5.1	102	2.26
77	do Rutland,	7.1	5.3	1.9		1.2	84.5	6.5	130	2.27
78	do Westminster,	5.3	3.8	2.2	3.0	0.7	85.0	4.6	92	2.26
79	do Royalston,	6.0	3.6	1.9		0.6	87.9	5.4	108	2.27
80	do Fitchburg,	5.4	3.3	1.0	2.1	0.7	87.5	3.4	68	2.44
81	do Petersham,	5.7	4.8	2.4		0.4	86.7	4.5	90	2.36
82	do New Braintree,	6.0	6.3	1.7		0.8	85.2	6.7	134	2.34
83	do Palmer,	5.7	2.7	2.1		0.6	88.9	2.6	52	2.49
84	do Enfield,	7.2	4.9	2.5		1.0	84.4	6.4	124	2.29
85	do New Salem,	3.2	2.7	1.5		0.7	91.9	3.7	74	2.44
86	do Leverett,	3.3	3.7	2.8		0.7	89.5	4.4	88	2.49
87	do Hardwick,	6.3	3.3	2.1		0.6	87.7	4.9	98	2.36
88	do Ware,	5.3	0.7	1.9		0.6	91.5	2.3	46	2.58
89	do Grafton,	4.5	3.5	2.1		0.6	89.3	5.4	108	2.39
90	do Brimfield,	5.3	2.1	1.0		0.4	91.2	3.7	74	2.46
91	do Leicester,	3.9	2.9	2.8		1.3	89.1	5.2	104	2.48
92	do Otis,	4.7	5.4	1.8		1.1	87.0	6.0	120	2.34
93	do Becket,	8.3	2.4	2.9		1.1	85.3	6.0	120	2.27
186	do Sandisfield,	3.2	3.3	2.5	2.8	1.5	86.7			2.32
185	do Tolland,	5.2	3.8	3.9		1.0	86.1			2.28
187	do Northfield, South Farms,	1.3	3.0	1.5		1.0	93.2			2.34
94	do Buckland,	5.4	2.0	2.1		0.7	89.8	2.8	56	2.51
95	do Wareham,	2.0	0.6	1.2		0.4	95.8	0.9	18	2.68
96	do Sturbridge,	5.1	3.7	2.3		0.4	88.5	2.7	54	2.50
97	do Brimfield, not cultivated,	0.6	3.8	1.1		0.5	94.0	3.7	74	2.60
98	do West Brookfield, not cultivated,	1.5	5.1	1.6		0.5	91.3	4.7	94	2.68
99	do Oakham,	4.8	2.2	1.4		0.3	91.3	3.0	60	2.55
100	do Athol, decomposing Gneiss,	0.3	5.3	2.0		0.3	92.1	3.0	60	2.60
101	Granite Soil—W. Hampton,	1.2	4.0	1.6		0.8	92.4	2.2	44	2.60

No.	NAME AND LOCALITY OF THE SOIL.	Soluble Geine.	Insoluble Geine.	Sulphate of Lime.	Carbonate of Lime.	Phosphates.	Silicates.	100 grains heated to 300° F. absorbed in 24 hours.	Absorbing Power in Proportional Numbers.	Specific Gravity.
102	Granite Soil, Concord, - - - - -	7.1	2.0	1.6		0,5	88.8	2.5	50	2.50
103	do Duxbury, - - - - -	4.0	2.0	0.8		0.7	92.5	2.4	48	2.43
104	do Andover, - - - - -	5.1	7.5	1.6		0.6	85.2	4.4	88	2.29
105	Sienite Soil—Lynnfield, - - - - -	5.1	5.2	1.4		0.6	87.7	4.4	88	2.29
106	do Marblehead, - - - - -	5.1	5.0	2.7		0.6	86.6	5.8	116	9.35
107	do Manchester, - - - - -	6.5	3.4	0.8		0.6	88.7	4.0	80	2.40
108	do Gloucester, - - - - -	2.4	2.2	1.5		0.3	93.6	2.8	56	2.25
109	do Lexington, - - - - -	5.4	3.9	2.6		0.6	87.5	6·5	30	2.24
110	do Danvers, - - - - -	3.8	6.9	2.7		0.7	85.9	5.0	100	2.34
111	do Newbury, - - - - -	5.0	5.5	1.0		0.5	88.0	5.3	106	2.36
112	do Dedham, - - - - -	7.0	4.7	1.0		1.3	86.0	6.2	124	2.24
113	do Wrentham, - - - - -	5.6	5.6	0.8	0.4	1.5	86.1	3.6	72	2.43
114	do N. Bridgewater, - - - -	2.2	5.9	2.5		0.7	88.7	3.7	74	2.36
115	do Weymouth, - - - - -	2.6	5.1	2.2		0.6	89.5	4.0	80	2.35
116	do Sharon, - - - - -	6.9	3.2	1.7		0.5	87.7	3.2	64	2.32
117	do Marshfield, - - - - -	1.6	2 9	1.1		0.8	93.6	3.7	74	2.45
118	do Abington, - - - - -	2.7	3.7	1.5		0.8	91.3	2.7	54	2.46
119	Porphyry Soil—Kent's Island, Newbury. -	5.7	4.6	3.3		0.4	86.0	6.3	126	2.26
120	do Medford, - - - - -	8.7	4.2	2.6		0.8	83.7	6.6	132	2.17
121	do Malden, - - - - -	5.2	4.1	3.5		1.6	85.6	6.8	136	2.26
122	do Lynn, - - - - -	4.3	3.5	1.8		0.6	89.8	5.9	118	2.29
123	Greenstone Soil—Ipswich, - - - -	2.8	9.4	0.7		0 2	86.9	3.6	72	2.22
124	do Woburn, - - - - -	7.7	4.6	1.3		1.2	85.2	6.0	120	2.27
125	do Deerfield, - - - - -	3.2	4.3	0.1	2.0	0.3	90.1	2.7	54	2.51
1[illegible]7	do New land never manured Belchertown.	2.3	4.6	2.4		1.0	89.7			2.35

Explanation of the preceding Table of Results with Remarks and Inferences.

The first and second columns need no explanation: and the character of the third and fourth will be fully understood, after reading the remarks of Dr. Dana that precede the Table. They show us the amount of nutriment in the soils of Masschusetts; also how much of it is in a fit state to be absorbed by plants, and how much of it will need further preparation. As this is probably the first attempt that has been made to obtain the amount of geine in any considerable number of soils, we cannot compare the results with those obtained in other places. They will be convenient, however, for comparison with future analyses: and we learn from them, that geine, in both its forms, abounds in the soils of the state, and that it most abounds where most attention has been paid to cultivation. It ought to be recollected, that I took care not to select the richest or the poorest portions of our soils; so that the geine in this table is probably about the average quantity. It is hardly probable that the number of specimens analyzed from the different varieties of our soils is sufficiently large, to enable us to form a very decided opinion as to their comparative fertility, especially when we recollect how much more thorough is the cultivation in some parts of the state than in others. It may be well, however, to state the average quantity of geine in the different geological varieties of our soils, which is as follows.

		Soluble Geine.	Insoluble Geine.
Alluvium,		2.37	2.13
Diluvial argillaceous soil,		3.87	4.73
Do Sandy,		1.52	1.30
Sandstone	do	3.28	2.14
Graywacke,	do	3.60	4.00
Argillaceous slate	do	5.84	6.06
Limestone,	do	2.88	3.51
Mica slate	do	4.10	5.10
Talcose slate	do	4.43	4.64
Gneiss	do	4.40	3.45
Granite	do	4.05	3.87
Sienite	do	4.40	4.50
Porphyry	do	5.97	4.10
Greenstone	do	4.00	5.72

One fact observable in the above results may throw doubts over the fundamental principles that have been advanced respecting geine; viz., that it constitutes the food of plants, and that they cannot flourish without it. It appears that our best alluvial soils contain less geine, in both its forms, than any other variety, except the very sandy diluvial ones. Ought we hence to infer that alluvium is a poor soil? I apprehend that we can infer nothing from this fact against alluvial soils, except that they are sooner exhausted than others, without constant supplies of geine. For if a soil contain enough of this substance abundantly to supply a crop that is growing upon it, that crop may be large although there is not enough geine to produce another. Now analysis shows that our alluvial soils contain enough of geine for any one crop: and I apprehend that their chief excellence consists in being of such a degree of fineness that they allow air, moisture, and lime, rapidly to convert vegetable matter into soluble geine, and yield it up readily to the roots of plants: but I presume that without fresh supplies of manure, they would not continue to produce as long as most of the other soils in the state. A considerable part of our alluvia are yearly recruited by a fresh deposite of mud, which almost always contains a quantity of geine and of the salts of lime, in a fine condition for being absorbed by the rootlets of plants. And on other parts of alluvial tracts, our farmers, I believe, are in the habit of expecting but a poor crop unless they manure them yearly. Yet so finely constituted are these soils, that even if exhausted, they are more easily restored than most others: so that taking all things into the account, they are among the most valuable of our soils: and yet I doubt whether they produce as much at one crop as many other soils; though the others perhaps require more labor in cultivation.

The amount of soluble and insoluble geine obtained by Dr. Dana's method of analysis, ought to correspond pretty nearly with the amount of organic

matter obtained by the old method; and by comparing the two tables of results that have been given, it will be seen that such is the fact. Several circumstances, however, besides errors of analysis, will prevent a perfect agreement. In the first place, by the old method of analysis, 100 grains of the soil are weighed before expelling the water of absorption; but by the new method, not until after its expulsion. Again, by the old method only the very coarse parts of the soil are separated by the sieve: but a fine sieve is used by the new mode, and this removes nearly all the vegetable fibre, which by the other method is reckoned a part of the organic matter. Other causes of difference might be named: and hence we ought not to expect a perfect agreement in the results of the two methods.

The two next columns in the Table contain the sulphate and carbonate of lime, and the third column the phosphates generally: in most cases probably it is the phosphate of lime: but sometimes of alumina and perhaps of other bases. I have already described the infrequency of the carbonate of lime in our soils: but it will be seen that I found the sulphate of lime as well as phosphates in every soil analyzed. In respect to the sulphate of lime, or gypsum, it may not be unexpected that we should find it in all soils, since we know it to occur in all natural waters throughout the state; and we cannot conceive of any other source from which the water could have derived it, except the soil. But the phosphates have generally been supposed to be much more limited, nay to be scarcely found in soils, except where animal substances have been used for manure. It is not possible that in all the soils which I have analyzed, such was their origin, for 13 of them have never been cultivated. And there is strong reason to believe, that phosphates are a constituent of all soils in their natural state. The arguments on this subject are stated so ably by Dr. Dana, that I need only quote from his letter.

"When we consider that the bones of all graminivorous animals contain nearly 50 per cent. of phosphate of lime, we might be at liberty to infer the existence of this principle, in the food, and, consequently, in the soil, on which these animals graze. If we look at the actual result of the analysis of beets, carrots, beans, peas, potatoes, asparagus, and cabbage, we find phosphate of lime, magnesia, and potash, varying from 0.04 to 1.00 per cent. of the vegetable. Indian corn too, by the analysis of the late Professor Gorham, of Harvard College, contains 1.5 per cent. phosphate and sulphate of lime. It may be said that this is all derived from the manure. We shall see by and by. Let us look at the extensive crops often raised, where man has never manured. Rice, wheat, barley, rye, and oats, all contain notable portions of phosphates of lime, not only in the grain but in the straw, and often in the state of superphosphates. The *diseases* too, *ergot* and *smut*, show *free phosphoric acid.* Can it be that, owing to certain electrical influ-

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ences of the air, in particular seasons, lime is not secreted by the plant to neutralize the free acid? May not this be a cause of smut and ergot? Does it not point out a remedy? Take too the cotton crop of our country. What vast quantities of phosphates do we thus annually draw from the soil? Cotton gives one per cent. ashes, of which 17 per cent. is composed of phosphate of lime and magnesia. The like is true of tobacco. It contains 0.16 per cent. of phosphate of lime. If we turn to the analysis of forest trees, we find that the *pollen* of the *pinus abies,* wafted about in clouds, is composed of 3 per cent. phosphate of lime and potash. May not this too be one of nature's beautiful modes of supplying phosphoric acid to plants and to soils? If, as the late experiments of Peschier have proved, sulphate of lime, in powder, is decomposed by growing leaves, the lime being liberated, and the sulphuric acid combining with the potash in the plant, why may not phosphate of lime, applied by *pollen,* act in the same way? At any rate, the existence of phosphate of lime in our forest soils is proved not only by its existence in the pollen, but by its actual detection in the ashes of pines and other trees.—100 parts of the ashes of *wood* of *pinus abies* give 3 per cent. phos. iron; 100 parts of the ashes of the *coal* of *pinus sylvestris* give 1.72 phos. lime, 0.25 phos. iron: 100 parts of ashes of oak coal give 7.1 phos. lime, 3.7 phos. iron;

100 ashes of	Bass wood	5.4	phos. lime,	3.3	phos. iron.
"	Birch	7.3	"	1.25	"
"	Oak wood	1.8	"		
"	Alder coal	3.45	"	9.00	"

"These are the calculated results from Berthier's very accurate analyses: and those very curious crystals—detected in some plants—the "*raphides*" of De Candolle, are some of them bibasic phosphates of lime and magnesia. Phosphate of iron, we know, is common in turf; and some barren and acid soils owe their acidity to *free* phosphoric acid. If we allow that our untouched forest soil contains phosphate of lime, it may be said, that this, being in small quantity, will be soon exhausted by cultivation, and that the phosphates, which we now find in cultivated fields, rescued from the forest, is due to our manure:—I give you the general result of my analysis of *cow dung,* as the best argument in reply. My situation and duties have led me to this analysis. I give you it, in such terms as the farmer may comprehend: water, 83.60; hay, 14,: biliary matter, (bile resin, bile fat and green resin of hay,) 1.275; geine combined with potash, (vegetable extract,) 0.95; albumen, 0.175."

"The hay is little more altered than by chewing. The albumen has disappeared, but its green resin, wax, sulphate and phosphate of lime remain, and when we take 100 parts of dung, among its earthy salts we get about 0.23 parts phosphate, 0.12 carbonate, and 0.12 sulphate of lime. Now, a bushel of

green dung as evacuated weighs about 87.5 lbs. Of this only 2.40 per cent. are soluble. Of this portion only 0.95 can be considered as soluble geine."

Western Soils.

In addition to the preceding arguments respecting the existence of phosphate of lime in the soils, I would state that I found it in every analysis which I have made of the Berkshire marls, the results of which I shall soon present. I have also recently analysed five specimens of soils from Ohio and Illinois, presented to me by H. G. Bowers, Esq., formerly of Northampton, in this state, and now resident in Illinois. They were take from some of the most productive spots in those states, and, in regard to some of them, it is certain, that no animal or any other manure has ever been applied by man, and at least one of them seems not to have been cultivated, so far as I can judge from its appearance. Yet all these soils contain phosphate of lime. The following are the results of their analysis; which I give, partly because of the subject under consideration, and partly because I thought it might be gratifying to compare the composition of some of the best soils at the west with those in Massachusetts.*

No.		Soluble Geine.	Insoluble Geine.	Sulphate of Lime.	Phosphate of Lime.	Carbonate of Lime.	Silicates.	Water of Absorption.	Remarks.
198	Rushville, Illinois,	7.4	2.5	3.4	0.6	1.5	84.6	6.3	
199	Sangamon co., do	4.9	5.6	1.2	0.4	1.3	86.6	6 3	
200	Lazelle county, do	7.6	13 8	1.4	0.4	3.3	73.5	9.5	Apparently never cultivated.
	Peoria county, do	3.1	4.8	3.5	1.0		87.6	5.7	
201	Scioto Valley, Ohio,	4.5	6.7	2.1	0.9	2.8	83.0	5.3	Cultivated 14 years without manure

The above soils are evidently of the very first quality: the geine being in large proportion, and the salts quite abundant enough, while there is still a small supply of carbonate of lime to convert more insoluble into soluble geine, whenever occasion demands. Still, if we compare the preceding analyses with some of those that have been given of the Massachusetts soils, the superiority of the western soils will not appear as great as is generally supposed. And there is one consideration resulting from the facts that have been stated respecting geine, that ought to be well considered by those who are anxious to leave the soil of New England that they may find a more fertile spot in the West. Such soils they can undoubtedly find; for geine has been for ages accumulating from the decomposition of vegetation in regions which have not been culti-

* The analysis of four of these soils in the dry way by alkali has been already given with the salts from the above Table.

vated: and for many years, perhaps, those regions will produce spontaneously. But almost as certain as any future event can be, continued cultivation will exhaust the geine and the salts, and other generations must resort to the same means for keeping their lands in a fertile condition as are now employed in Massachusetts; viz., to provide for the yearly supply of more geine and more salts.

Mode of testing the Phosphates obtained by Dr. Dana's Rules.

If the results which I have given as to phosphates in soils be admitted as correct, they will settle the question, when taken in connection with Dr. Dana's reasoning, as to the very wide if not universal diffusion of this class of salts. But since Dr. Dana's rules imply that the process for obtaining them may also produce a little iron, and perhaps alumina, the enquiry arises, whether in some instances at least, what I have given as phosphates, may not in fact be only iron and alumina. I determined, therefore, to test some of these results. In doing this, I have followed two methods, appended by Dr. Dana to his rules already given for the analysis of soils; but which were not inserted in my report of 1838. I give them in his own language.

"As to the best mode of detecting phosphates in soils, (I say *phosphates*, because the third rule of analysis includes all phosphates under phosphate of lime,) there are two modes which I would suggest.

"1. Having reduced the analysis to the point at which the 3d rule estimates the phosphate of lime, dissolve that in pure acetic acid. Treat the solution with sulphuretted hydrogen to separate any iron and manganese; warm it to drive off the excess of sulphuretted hydrogen, and then treat the clear solution with acetate of lead. Phosphate of lead falls if any phosphoric acid is present—The only source of error is in the presence of sulphate of lime. The rule supposes that to be removed. If you doubt, collect the supposed phosphate of lead; dry, fuse on charcoal, in the outer flame of the blowpipe: phosphate of lead *crystalizes* as it cools. So says Berzelius and he considers this test infallible."

"2. Fuse the phosphate of lime of Rule 3 of analysis, with carbonate of soda. Dissolve in water, saturate the solution with nitric acid. If a precipitate occur it is subphosphate of alumina. Treat the clear solution with nitrate of silver; a *yellow* precipitate occurs if phosphoric acid is present. The lime in both cases may be separated by an oxalate as usual."

It is possible that a phosphate may exist in a soil and yet not be detected by either of these rules. Hence in a doubtful case, it may be well to fuse some of the finer part of the soil with alkali, and then treat the resulting solution as in the second of the above rules.

I applied the above rules to several of the phosphates obtained from soils, with the following results.

No. of the Soil.	Amount of the Phosphates used.	Action of acetate of Lead on the Acetic Solution.	Action of the Oxalate of Ammonia.
192	0.41	Precipitate	No trial
189	0.40	Do.	Do.
183	1.33	Do.	Precipitate slight
186	1.13	Do.	Do. larger
196	1.03	Do.	Do. small
176	1.30	Do.	Do. larger
179	0.90	Do.	Do.
178	0.09	Do.	Do.
191	0.60	Do.	Do.
185	1.50	None	Do.
2d. Trial	1.00	Do.	Do.
187	1.18	None	Do.
2d. Trial	1.04	Do.	Do.
203	0.81	Precipitate	Do. slight
204	0.12	Do.	Do. Do.

Although Nos. 241, and 242 gave no precipitate with acetate of lead, I was led to suspect that the phosphates might exist, but had become nearly insoluble by ignition; as is often the case (*Rose's Analytical Chemistry by Griffin, p.* 261). Indeed, in nearly all the cases described above, a considerable residuum remained after digestion in acetic acid. I determined, therefore, to attack Nos. 241, and 242 with several others, by means of carbonate of soda, and the results are given in the following table; which it will be seen confirm my suspicions as to the presence of phosphoric acid in Nos. 241, and 242.

No. of the Soil.	Effect of Saturation with Nitric Acid	Action of Nitrate of Silver.
185	Slight Cloudiness	Yellow Precipitate—abundant.
187	Do.	Do. Do.
194	Do.	Do. Do.
197	Do.	Do. only slightly yellow
179	Do.	Do. very yellow

I cannot see why the above trials do not satisfactorily show the presence of the phosphate of lime in all the 15 soils and marls that were operated upon; and the probable presence of subphosphate of alumina in five of them: yet as to this last point, I do not feel very confident, because the precipitates were very slight. These results were so satisfactory, that I did not think it necessary to subject any more soils to a similar process. I will not say that I should have found phosphoric acid in every soil, whose analysis I have given: but I feel justified in inferring from these trials, that it does exist in nearly every one of them. If any one should make use of Dr. Dana's rules for the analysis of soils, and are in doubt as to the phosphates, the rules above given will enable him to settle the question.

It is certain however, that Dr. Dana's method of determining the presence and amount of the phosphates in a soil by muriatic acid, does usually separate some iron, which is mixed with the phosphates; for in most cases, the results are more or less colored by the per oxide of iron. Possibly also a little alumina may thus be separated, yet I think this so minute in quantity that it need not be taken into the account. It becomes, however, an interesting enquiry, how large a proportion of iron is mixed with the phosphates. I made a few trials to determine this point. It has been already stated, that only a part of the phosphates were soluble in acetic acid. The insoluble residuum was digested in muriatic acid, which probably took up all the iron, although a small insoluble portion of matter still remained. The iron was precipitated by ammonia, and the following is the result.

The amount of matter left undissolved by acetic acid in the phosphate from Nos. 189, 183, 186, 196, 203, 204, and 176, (amounting to 6 grains) was 3.76 grains; which digested in nitromuriatic acid, left a residum of 0.46 grains; and ammonia threw down from the solution 2.22 grains. This divided by 7, gives 0.31 for the amount of iron in each soil; or about one third part of the supposed phosphates. The phosphates from the following soils were tried separately by muriatic acid and ammonia, with the following results.

No.	Amount of Phosphates.	Residuum from Acetic Acid.	Peroxide of Iron.
179	0.90	0.73	0.1
178	0.09	0 04	0 0
191	0.60	0.43	0.1
185	1.50	0.93	0.1
187	1.18	1.00	0.23

The amount of iron in these last examples is much less than in the first; yet taking all things into consideration, I should be disposed to reduce the amount of the phosphates, given in the general table of analysis, one third; and I think we may safely calculate that the residual numbers will not at least exceed the actual amount of the phosphates in the soils of Massachusetts.

Combinations of Phosphoric Acid in Soils.

It is rendered probable by the preceding results, as well as by general considerations, that phosphate of lime is the most usual form assumed by phosphoric acid in soils. But Dr. Dana has come to the conclusion, founded uponsome analytical trials, that a large portion of the phosphoric acid exists in combination with alumina. He says, "In the few trials I made, I found

subphosphate of alumina in the soils. Phosphate of alumina is so very difficult to separate and distinguish from pure alumina, that I have no doubt the absence of phosphoric acid in soils has been here overlooked. The subject needs further investigation." In a recent analysis of a rich soil from the state of Maine, Dr. C. T. Jackson has discovered 3 per cent. of subphosphate of alumina. (*Third Report on the Geology of Maine, p.* 150.)

The importance of the question whether phosphates exist generally in our soils, must plead my apology for dwelling so long upon it. If the views here advanced should prove true, it will be an important step gained in agricultural chemistry. If they prove false, I shall have the consolation of knowing that I have erred on a very difficult subject: and that I am in good company. I expect and wish that my views should not be received without thorough examination. Nor shall I be offended if the result at which I have arrived should be imputed to errors of analysis; provided chemists will themselves respeat these experiments. I would remark however, that in the application of Dr. Dana's rules for detecting the phosphates, it seems hardly possible for a mere tyro to commit much error, provided he possess pure muriatic acid;—a point which I endeavored to make sure by distilling it with a Wolf's Apparatus. To cause this acid to pass through a soil upon a filter, so as to get a transparent solution, does not surely require much skill: and then nothing remains but to evaporate this solution to dryness, and treat the residuum with water: so that it seems hardly possible to impute the existence of an insoluble residuum to any error in analysis.

Importance of Calcareous Matter in Soils.

It will be seen from the numerous analyses of Massachusetts soils that have been given, that lime in some form, and generally in several forms, exists in them all. Indeed, since this substance is found at least as a silicate in nearly all the rocks, we might expect it in all soils. Besides, vegetation itself, when it decays, furnishes a supply. The fact of this universal diffusion of lime is a presumptive argument, as has been already maintained, in favor of its importance, if not necessity, for the production of healthy vegetation. And numerous experiments that have been made, especially in Europe, confirm this opinion. For in a vast majority of cases, the addition of lime, either as quicklime; or as marl, or ground limestone, which are carbonates; or as gypsum, which is a sulphate; or as pulverized bones, which are phosphate; increases the fertility of land: and after a few years it becomes desirable to add another quantity. From hence it follows, that the lime in a soil is gradually used up, like the geine, by entering into the composition of the plants, growing upon it. And in such soils as those of Massachusetts,

probably all the lime would ere this have been exhausted, did it not exist in a state of such intimate combination, as to be extracted with difficulty. The rootlets of plants probably possess the power of decomposing the geate, and even the silicate of lime; and every other earthy combination most likely, by means of galvanic agency. It seems, however, that only a very small quantity of lime is essential to supply the immediate wants of the plant; and a soil that is half lime does not appear to be more productive than one containing 2 or 3 per cent.; though the former will retain its fertility a greater length of time. Lime also seems in many instances to exert an important influence in bringing geine into a proper state, to be taken up by the plants; as will be more fully shown farther on.

It is difficult to make a man not conversant with chemistry, realize that a crop may often fail upon his land from the absence of one or two per cent. of some substance, which, when present, analysis only can detect. Yet the chemist will not hesitate to admit the truth of this position: and the ingredient, whose presence is so important, may sometimes be lime. As this is unperceived by the farmer however, and as the state of the weather and other more common causes of the failure of crops are obvious, it is apt in all cases to be referred to them.

The numerous instances in which lime applied to land has seemed to produce no effect, has led some to infer that this substance is of no use upon soils. By such reasoning it would be easy to prove that every kind of manure is useless: for there is not one of them that does not sometimes prove useless, perhaps not as often as lime does, yet the principle of reasoning involved is the same in both cases: and it is a faulty one. For in both cases we can point out reasons why failures should sometimes occur. In respect to manures, these usually result from the state of the weather, using that term in its most extended sense. But in respect to lime, the failure may result from the fact, that the soil already contains enough of that substance for present use; or from the fact that there is no acid in the soil to be neutralized, and no vegetable matter in a state to be beneficially acted upon. Then again, it ought to be recollected that lime rarely produces any very visible effect for a year or two; and such may be the amount already in the soil, and such the state of the geine, that even 4 or 5 years are not long enough to prove that the lime does no good, for if vegetation does exhaust the lime in soils, the time will come, when that which has been artificially supplied will come into use; although from the nature of the case, it might be impossible to prove when this took place, because we know not when that natural to the soil would become exhausted. To be sure, in such cases the application of lime would be to benefit posterity, rather than ourselves; and the application might as well be delayed.

There may be other causes why lime seems to produce no effect upon soils—causes, which in the present state of our knowledge on the subject, we may be unable to understand: nor do I believe that the agricultural chemist, by the aid of the most accurate analysis, can in all cases certainly predict that lime will, or will not, be beneficial. He may be tolerably confident that a highly calcareous soil does not need it;—as experience proves in England. And if we adopt the views of Dr. Dana, which I shall shortly introduce, as to the mode in which lime acts upon soils, we may go a step farther; and say that it will not produce any striking effects unless there be acid in the soil to be neutralized, or organic matter in such a state as to be converted into a geate, or into soluble geine. Beyond this we can scarcely go: and hence experiment is the only sure mode of determining the effect of lime upon our soils.

Some maintain, indeed, that the quantity of lime in a soil remains always the same. But is it not certain that most vegetables contain lime. Now if these are suffered to decay upon the land, or an equivalent supply is furnished by manure, the position is correct. But when crops are removed, as is usually the case, in far greater quantity than the manure returned, whence is the deficiency of lime thus carried off to be supplied? It cannot come from the atmosphere, nor from rain water; though the water of springs usually contains a small quantity of sulphate of lime. Or if no lime is abstracted from the soil, how can it need a fresh application of this substance after an interval of a few years; as we know to be the case where lime is found to be beneficial once?

But after all, the grand enquiry is, what upon the whole has been the effect of the application of lime upon soils not already saturated with it? In Great Britain, where the experiment has been made under the most enlightened superintendence and on a most extended scale, the result is very decided. "Lime," says one of the writers of that country, "has long been applied by British husbandmen, as a stimulus to the soil; and in consequence of such an application, luxuriant crops have been produced, even upon soils of apparently inferior quality, and which would have yielded crops of trifling value had this auxiliary been withheld. In fact the majority of soils cannot be cultivated with advantage till they are dressed with lime; and whether considered as an alterative, or as a stimulant, or as a manure, it will be found to be the basis of good husbandry, and of more use than all other manures put together. Wherever lime has been properly applied, it has constantly been found to prove as much superior to dung, as dung is to the rakings of the roads or the produce of a peat mire."—*Morton on the Nature and Properties of Soils, &c." London,* 1838. *p.* 182.

Now suppose that the comparatively few imperfect experiments on

the use of lime which have been made in this country had nearly all failed to prove lime beneficial, should we be justified in infering that British agriculturists have so long been mistaken? Ought we not rather to infer, that we had not yet discovered the proper mode of applying lime, which in our climate may need to be applied in a manner somewhat modified, though this is not very probable. But what in fact is the experience of American farmers on this subject? The same, I answer, as in England, in France, and other European countries; viz, that in a great majority of instances lime is an excellent manure, though sometimes it seems to produce no effect, from causes not always discoverable. Lime, however, has not been as yet very extensively employed in our agriculture; partly from the dearth of the material in the older settlements, and partly from there being less need of it in a new country, where the land has been growing richer and richer for ages. In many parts of New York, Pennsylvania, Virginia, &c. however, lime is extensively employed. But in Massachusetts its use as a manure has been very limited. Even in Berkshire County, where the carbonate is so abundant, but few experiments have been made on this subject. In some other parts of the State insulated but successful experiments have been made with lime, which I shall mention more particularly when I come to describe our marls and limestones. The sulphate of lime has been used more extensively, I apprehend, in Massachusetts, and with more marked success, than lime in any other form: and the phosphate, or bones ground into powder, is beginning to be used in the vicinity of Boston very successfully. In short, it must be strong prejudice, or a defective philosophy, which leads any one to decry the use of lime upon soil, because his own experiments, or those of his neighbors, have failed. I acknowledge that the few trials which I have made with caustic lime have had little apparent success. But how unphilosophical hence to infer that the long and enlightened experience of Europeans, and much in our own country, is to go for nothing!

It is a very prevalent opinion in New England, that lime is especially necessary for the successful cultivation of wheat: that is, more necessary than for most other crops. Now analysis leads to an opposite conclusion: for while only 37 per cent. of lime exists in the ashes of wheat, 66 per cent. is found in potatoes. Nor have I seen any evidence that wheat will not grow as well as potatoes without the application of lime: and since our citizens have turned their attention for several years past to the cultivation of wheat, many facts in support of this opinion have come out. According to the views that have been advanced, the grand point is to bring the geine of the soil into a proper state for immediate nourishment; and ashes would probably accomplish this more effectually than lime. The best crop of wheat raised in Amherst, in the year 1838, was grown upon the soil not limed, derived from coarse granite,

whose feldspar probably yielded potassa, a substance eminently adapted to render the geine soluble.

Nature of Geine.

From the statements that have been made, it appears that Sprengel, Boullay, and Berzelius, regard Geine, or *Humus*, as a distinct and peculiar compound, made up chiefly of oxygen, hydrogen, carbon and nitrogen. This view of the subject, however, has been strenuously opposed by M. F. V. Raspail, a French chemist of distinction, in his New System of Organic Chemistry, translated and published in London in 1834. He denies the existence in vegetables and soils of any such proximate principle as geine, and says, "it will be easy to see that all these phenomena, (described by Berzelius and others,) apparently so varied, which have given room for the discovery of so many substances analogous in their nature to Ulmin, are essentially nothing but a developement of carbon! He must of course maintain that this carbon is never dissolved, but only suspended in a fluid! Plants he conceives are nourished almost entirely by carbonic acid; and he says that "possibly by supplying artificially to the plant the carbonic acid which is necessary to its growth, the use of any kind of manure may be dispensed with." These reasonings of Raspail did not lead Berzelius to change his views respecting geine; but rather to maintain more decidedly his previous opinions in a subsequent publication.

More recently some chemists have advanced the opinion that soluble geine is composed of at least three vegetable acids;—the crenic, the apocrenic, and ulmic; with a black matter called *earthy extract*; and that insoluble geine is ulmic acid mingled with undecomposed vegetable remains. (*American Journal of Science, Vol* 36. *p.* 369.) Dr. Charles T. Jackson has made numerous experiments on this subject of late, and, as stated in a letter, he thinks he has "satisfactorily proved that there is no such thing as *geine*; but the substances which have been mistaken originally by Berzelius, and subsequently by Dr. Dana, for a simple substance, really consist of a compound of the two new acids (crenic and apocrenic) discovered by Berzelius shortly after the publication of his first account of Geine and Apothem." These exist "with occasionally a small proportion of phosphoric acid and perhaps also of oxalic acid: these acids often being in combination with calcareous, magnesian, manganesian and ferruginous bases."

I have not thought it necessary for me to go in this place into a discussion of these various opinions respecting the nature of geine. As to that of Raspail, who supposes it to be mere carbon diffused not dissolved in water, &c. I can hardly believe it will be adopted by any one who has gone through many processes with this substance; and has seen especially how decidedly it is often precipitated by reagents. If its mixture with liquids be not a real solution, I can hardly expect to distinguish a solution in any case. As to those views which suppose geine to be a mere mechanical mixture of crenic and apocrenic acids, (to lay aside all doubts about their distinct existence,) I would merely enquire, whether the occurrence of these acids in the organic matter of soils, proves that geine has no distinct existence?* Why may it not be a compound of these, and perhaps other acids, and other ingredients? Does not the fact that these two acids are uniformly present in soluble geine, render it probable that they do enter into chemical combination to form such a compound substance? If I understand Dr. Dana's views of the nature

* An excellent paper on the Physical Properties of Soils has lately appeared in the first Volume of the Journal of the English Agricultural Society, by Professor Schuhler of Tübingen. He gives the composition of 28 varieties of soil, analyzed by himself, Prof. Gieger, and Dr. Sprengel, under the terms, *Sand: Clay, or Deposite: Humus;* and *Volatile Matter*. But for some reason or other, he makes no allusion to crenic or aprocrenic acid, nor to any of the new views respecting geine. Except what this fact would indicate, I confess myself unable to say how far these views have been adopted by scientific men in Europe.

of geine, they are not inconsistent with such a supposition; though he has said but little in his communications to me on this point. But in a letter to Mr. Colman, given in his Second Agricultural Report, p. 165, he has given an analysis of 3.6914 grains of soluble geine, as follows:

Geine,	1.9258
Alumina and Oxide of Iron,	.7715
Phosphoric Acid,	.2315
Magnesia,	.3396
Loss,	.4230
	3.6914

Dr. Dana adds: "I presume that the soluble geine of all soils is similarly constituted. All which I have examined affords these elements." Now if phosphoric acid, alumina, &c. may form elements of geine, why may not what is called *geine* in the above analysis, consist of crenic and apocrenic acids, in perfect consistency with Dr. Dana's views?

But suppose it be admitted that these various acids and oxides do not form chemical but only mechanical mixtures in the soil. Yet most scientific men will allow that they constitute that portion of the food of plants which is derived from the soil; and if Dr. Dana's rules of analysis will show us how much of them the soil contains, and what part is in a soluble state, or in a state in which it can be immediately taken up by the organs of plants; and what part is in an insoluble state, unfitted for immediate use; I really cannot see why those rules are not just as valuable, whether geine be a distinct compound, or whether it be composed of crenic, apocrenic, phosphoric, and oxalic acids, casually mixed together. If Dr. Dana's rules do not point out the best mode of accomplishing these objects, and any chemist will suggest a better one, I am sure no one will more cheerfully substitute the improved methods for those proposed in this report, than the author of them. But even though such improvements should be proposed, the credit will still belong to Dr. Dana, of having first suggested this mode of analysis; and of having at the very outset proposed rules remarkable for their simplicity and ease of application. They are such rules as could have been furnished only by one who was thoroughly conversant with the theory and manipulations of chemistry, whose life in fact had been devoted to the subject. They are indeed, suggested by Dr. Dana only as rules for the intelligent farmer: although some have understood them as intended for the accomplished analyst. And indeed, I believe them capable of so accurate an application that even such a man may find them of great benefit.

There is another point on which I conceive Dr. Dana to have been misunderstood. It has been thought that he would make geine the sole food of plants, and deny the current opinion that they have the power of absorbing carbonic acid from the atmosphere and perhaps from the soil. But I do not thus understand him. I suppose he means only, that geine is one of the sources—though a most important one—from which vegetables derive their nourishment; but not the only one. Nor would he deny probably—though here I speak without any certain knowledge—that plants may have the power, to a certain extent, of adapting themselves to their condition, so that when they cannot obtain nourishment in one mode, they may get the more in some other mode. Without such a principle I cannot see how all the phenomena of vegetable development can be explained.

Dr. C. T. Jackson's Mode of Analysis.

It may be desirable to present a mode of analyzing soils, such as one would adopt who believes there is no such compound as geine; and that crenic and apocrenic acids exist in the soil in an insulated state. Dr. Jackson has adopted such a mode in analyzing the soils of Rhode Island;

which will appear in his report upon the geology of that state: and he has obligingly furnished me with a brief sketch of his method, which I now present in his own words.

"1. Dry the soil at a temperature a little above 212°; say 240° at the highest. Dry your filters at the same temperature.

"2. Take 100 grains, or if you please, 1000 grains of the soil, in its dry state, for the separation of the organic matters. Put this into a French green glass flask of 6 oz. size, and fill the flask up to the base of the neck, with a saturated solution of the carbonate of ammonia in distilled water. Digest the soil at 240°, or thereabouts, for 36 hours: or you may safely boil the whole. Decant upon a double filter: pour on another charge of carbonate of ammonia, and repeat the operation until the ammoniacal solution comes off colorless. Then wash out the whole contents of the flask upon the filter. Wash with hot water, until no trace of the ammonia is left: then dry the filter and its contents at 240° and weigh: the loss is the soluble vegetable matter. Burn the residue in a plantium crucible in the muffle: the loss is the insoluble vegetable matter.

"3. Take now your solution: acidulate it with pure acetic acid, and drop in a solution of the acetate of copper, or even a solution of pure crystalized verdegris. A brown precipitate will rapidly form, which is the apocrenate of copper. Let the solution stand over night in the drying closet, or some warm place: all the apocrenate will subside. This you may collect on a carefully counterpoised filter, and weigh when dried; or you may wash it in the jar repeatedly, and mixing it with a little distilled water, you may decompose it by a current of sulphureted hydrogen; which will throw down all the copper, and then you may separate the solution of apocrenic acid, evaporate to dryness slowly, (or over sulphuric acid under the air pump,) and weigh it by substitution. Next render your solution highly alcaline, by means of carbonate of ammonia: boil it to drive off the carbonic acid. Drop into it, when cold, acetate of copper in solution. A whitish green precipitate of crenate of copper falls, and will collect abundantly by letting the solution stand in a warm place over night. Collect your crenate and weigh it by the double counterpoised filters; or wash it and decompose it as you did the apocrenate, and you will have a straw colored solution of crenic acid. Evaporate to dryness over concentrated sulphuric acid, and weigh by substitution. The crenic acid looks like a varnish on the inside of the capsule. Dissolve and test it. You will frequently find in it crystals of phosphate of ammonia, also, from the phosphoric acid in the soil: and I have always found this acid in my analysis of peat. When you have obtained a pure crenate or apocrenate of copper, you may analyze it by the process of deutoxide of copper; or more simply, you may deflagrate it with nitre and separate the copper n the state of deutoxide and deduct it from the weight of the crenate employed, and you will have the quantity of the crenic acid. Acetate of lead throws down all the crenic and apocrenic acid from a slightly acidulated solution, made by carbonate of ammonia. Muriatic acid throws down apocrenic acid in brown flocks from the ammoniacal solution. Lime water does not throw down all the crenic acid: for the crenate of lime is highly soluble."

Silicates.

When the geine and the salts that have been described, chiefly those of lime, have been extracted from a soil, the residue is mostly a compound of silica with alumina, iron, lime, magnesia, &c. usually called *Silicates*, because the silica is regarded as acting the part of an acid; although its compounds are not commonly denominated salts. These silicates occupy the eighth column of the preceding table of analyses; and their amount was

obtained by subtracting the geine and salts from 100. Concerning the nature of these silicates, I have nothing farther to add, to the extended remarks already made on this subject.

Power of Soils to absorb Water.

It is generally known, that soils possess the power of absorbing moisture in different degrees. This power depends more upon the geine, than any other principle. Alumina stands next on the list in its degree of absorbing power; next, carbonate of lime; and least of all, silica. Hence there ought to be a general correspondence between the absorbing power of a soil and its fertility; and, therefore, this property affords some assistance in estimating the value of a soil. On this account I was desirous to get the power of absorption possessed by the soils of Massachusetts. 100 grains were heated to 300° F. and then exposed on a small earthern plate for 24 hours, in a cellar, whose temperature remained nearly the same from day to day. The thermometer stood in it at 37° F.; and the *dew point*, by Daniell's Hygrometer, was at 33° F. At the end of 24 hours, the soils in the plates were again weighed, and the number of grains which they had gained was put into the ninth column. For the sake of showing at a glance the absorbing power, it is expressed in the tenth column by proportional numbers; 5 grains absorbed, being equal to 100.

I find the winter to be a most unfavorable time for experiments of this sort; and I place but little reliance upon the results which I have obtained. As the experiments were performed, however, with a good deal of care, I thought it best to give them, after stating all the circumstances under which they were made.

Power of Soils to retain Water.

It is well known that some soils will bear a drought better than others. This may be owing to three causes: 1. one soil may have more power to retain water than another: 2. one may absorb more water than another during the night: 3. one may have a subsoil less pervious to water than another. When these three causes combine, they may operate powerfully upon the ability of a soil to resist long continued drought. But when one operates differently from the others, they may in a measure neutralize one another. Hence it may be doubted whether direct experiments in the small way upon the power of soils to retain water, will give their real power. Yet since we have reason to believe the retaining power to be in direct proportion to the absorbing power, the forces above mentioned will rarely if ever act in opposition; and hence, I thought it might be desirable to perform some experiments on the subject. Those which I gave in my Report of 1838, were made in the

winter, and on different days, when the temperature and the dew point were different; so that they could not be directly compared. Hence I was led to repeat them with some variation, during the summer of 1839. I confess that I do not see what important results can be derived from them. But as they are the first trials of the kind with which I have met, they may be useful to compare with others that may be hereafter made: and therefore I shall detail them.

200 Grains of each soil were spread upon earthern plates of about 3 inches diameter; and the weight of the whole obtained. By means of a graduated dropping tube, 100 grains of water were added to each plate: when, at 9 o'clock A. M. June 25th. they were all at the same time exposed, in a situation sheltered from the wind, to the direct rays of an almost cloudless sun, for 3 1-2 hours; when all were removed to a dry room and weighed. The loss of weight is given in the second column in the annexed Table: the first column indicating the number of the soil which corresponds to those in the state Collection. During the following night the plates were exposed without removing the soils, to a cloudless atmosphere, and weighed in the morning. The gain is given in the third column. Next morning, June 26th, 100 grains of water were added to each plate, and the whole exposed as before, to the sun, from 8h. 30m. till 11 hours, when they were weighed as before, and the loss constitutes the fourth column. Remaining in a dry room till July 1st. they were again exposed without adding water, to the sun, from 11 to 3 o'clock and then weighed, and the loss constitutes the fifth column: although in this case, it will be seen, that there were numerous failures.

It will be seen from the above statement, that the third column shows the absorbing instead of the retaining power of the soils.

The following was the state of the thermometer and of Daniell's Hygrometer on the days when the experiments were made.

June 25th. 1839.	
Thermometer at 9 hours A. M.	72°
Dew Point at that hour	58
Thermometer at 12h. 30m.	79
Dew Point	52
Thermometer at 8 hours P. M.	72
Dew Point	53
June 26th.	
Thermometer at 8h. 30m.	70°
Dew Point	60
Thermometer at 11h. A. M.	75
Dew Point	58
July 1st.	
Thermometer at 11h. A. M.	77°
Dew Point	64

Experiments on the Retaining Power of Soils.

No.	Loss of 200 grs. in 3 1-2 hours June. 25	Gain at night	Loss in 2 1-2 hours June 26.	Additional loss in 4 hours July 1.
1	100	5	100	6
2	96	7	98	8
3	93	6	99	7
4	100	7	105	3
5	102	8	103	6
6	100	5	103	4
7	99	8	101	2
8	103	8	105	4
9	99	9	101	8
10	102	9	105	5
11	100	7	105	3
12	101	7	97	10
13	100	7	101	8
14	102	8	102	8
15	101	5	103	
16	101	7	104	
17	101	7	104	
18	100	5	108	
19	95	6	107	
20	99	4	102	
21	101	6	109	
22	100	4	104	
23	88	5	109	
24	101	6	104	
25	101	4	108	
26	103			
27	102	9	101	8
28	101	7	104	5
29	100	7	97	12
30	102	10	105	5
31	101	10	108	4
32	98	11	108	5
33	102	12	103	9
34	100	11	103	9
35	82	14	102	14
36	101	9	104	6
37	97	12	108	4
38	101	12	107	5
39	101	11	106	7
40	101	13	102	13
41	92	13	105	
42	101		104	
43	106		112	

No.	Loss of 200 grs. in 3 1-2 hours.	Gain at night.	Loss in 2 1-2 hours.	Additional loss in 4 hours.
44	105	17 (?)	112	
45	106	14	111	
46	103	13	100	
47	100	9	106	
48	102	9	100	
49	103	11	111	
50	102	8	105	
51	102	11	105	8
52	102	13	104	9
53	102	12	103	10
54	103	13	103	11
55	103	10	101	12
56	101	7	100	9
57	102	9	106	
58	104	15	105	
59	100	12	103	
60	102	8	108	
61	102	9	104	
62	101	8	100	4
63	103	14	108	5
64	104		108	4
65	105	17 (?)	105	9
66	114	13	107	6
67	104	12	108	4
68	96	5	110	
69	107	15	109	1
70	106	12	106	2
71	104	11	106	3
72	104	9	107	0
73	109	13	104	1
74	104	7	91	14
75	99	7	93	12
76	101	9	97	10
77	101	10	101	5
78	102	9	105	1
79	100	9	102	5
80	102	12	111	1
81	101	13	111	10
82	101	5	95	
83	104	9	107	
84	106	10	104	
85	106	8	104	
86	103	6	102	
87	109	13	104	
88		11	105	
89		14	106	5
90		12	108	1

No.	Loss of 200 grs. in 3 1-2 hours.	Gain at night.	Loss in 2 1-2 hours.	Additional Loss in 4 hours.
91	108	18	109	3
92	100	8	105	5
93	102	12	108	5
94	100	4	103	3
95	104	7	103	1
96	103		102	1
97	102	11	110	2
98	103	12	109	3
99	102	12	109	3
100	101	11	106	5
101	103	10	110	
102	101	8	108	
103	101	9	110	
104	102	10	105	
105	102	8	109	
106	101	6	109	
107	102	9	110	
108	101	10	108	
109	103	10	105	
110	104	10	105	
111	101	4	98	9
112	102	8	101	9
113	100	3	100	6
114	101	5	105	1
115	102	4	99	6
116	101	3	100	14
117			102	4
118	100	0	99	
119	102	4	100	
120	102	3	101	
121	103	2	100	
122	103	2	102	
123			104	8
124	106	13	104	8
125	101	1	100	0
126			92	3
127	102	8	105	3
128			107	1
129	103	9	106	2
130	103	9	104	2
139			107	3
143			102	4
146	94	2	107	5
148	86	3	89	26

All the numbers in the above table over 125, belong to specimens of clay, muck sand, or marl; all of which will be described in other parts of my Re-

port. The results exhibit nothing of importance on which to remark, except perhaps that the specimen of marl (No. 148) appears to possess the strongest retaining power of all the substances tried: and this fact may suggest to us one of the causes that render marls valuable upon land. It will be seen, in the second column, that though only 100 grains of water were added, more than that quantity was usually given off in the course of 3 1-2 hours. This fact led me to expose the soils only 2 1-2 hours the next day; yet even then, more than, 100 grains were usually given off, because of the quantity of moisture absorbed during the night. At the third trial, whose results are given in the last column, I determined not to add any water, and to expose the plates a longer time, and since the last portions of water are always driven off with the most difficulty, I suspect that this last column exhibits better than the others, the relative power of the different soils to retain water in time of drought. I regret, therefore, that an accident has prevented this column from being complete.

Power of Soils to absorb Oxygen from the Atmosphere.

In the excellent paper by Prof. Schubler on the Physical Properties of Soils, referred to on page 55, I find numerous experiments and remarks, not only upon the power of soils to absorb and retain water, but also oxygen gas and heat; as well as their electrical and other relations of importance. But I have room to notice only a few of the new and interesting views which he has presented. *See Journal of the English Agricultural Society, Vol 1 p.* 177. *Lond.* 1839.

Humboldt first pointed out the power of soils to absorb oxygen from the atmosphere: but his views were contradicted: yet they seem now fully established by Schubler. The following Table shows the amount of oxygen absorbed in 30 days, from fifteen cubic inches of air, by 1000 grains of the different soils named. In a dry state they absorbed none.

Siliceous Sand,	1.6	0.24	0.10
Calcareous Sand,	5.6	0.84	0.35
Gypsum Powder,	2.7	0.40	0.17
Sandy Clay,	9.3	1.39	0.59
Loamy Clay,	11.0	1.65	0.70
Stiff Clay or Brick Earth,	13.6	2.04	0.86
Grey pure Clay,	15.3	2.29	0.97
Fine Lime,	10.8	1.92	0.69
Magnesia,	17.0	2.66	1.08
Humus, (Geine,)	20.3	3.04	1.29
Garden Mould,	18.0	2.60	1.10
Arable Soil,	16.2	2.43	1.03
Slaty Marl.	11.0	1.65	0.70

It appears from this Table, that Humus or Geine, absorbs more oxygen than any other soil: And Prof. Schubler says, that it enters into chemical combination with the geine, giving it a higher degree of oxygenation; and that some carbonic acid also is produced. Whereas no chemical union is formed between the other soils and the oxygen absorbed. Here then, we see another mode in which that wonderful substance, geine, acts as a fertilizer: viz. by furnishing carbonic acid and oxygen.

Galvanic and Electrical Relations of the Soils.

According to the same writer, the pure earths, such as sand, lime, magnesia and gypsum, when dry are non-conductors of electricity: but the clays and compound clayey earths are imperfect conductors. All the earths, when oblong dry pieces of them are scraped with a knife, develope negative electricity.

When solutions of Humus—that is, the salts of geine—are exposed to a current of galvanic electricity, decomposition immediately results. The geine collects around the positive pole, while the earths, or alkalies, collect around the negative pole. Do not these facts tend to confirm the views of Dr. Dana respecting the mode in which geine is taken up by the roots of plants; viz. by their forming galvanic combinations with the salts and earths in the soil, whereby the geine and the oxides are decomposed? Do they not, also, strengthen his opinion that geine is a distinct substance, which acts the part of an acid? If it be not a definite chemical compound, how could it be separated and go to the positive pole, by galvanism?

This paper of Prof. Schubler is certainly an important contribution to Agricultural Chemistry; and I regret that it did not fall under my notice, or rather, that it had not been published, when I was prosecuting experiments upon the soils of Massachusetts.

Specific Gravities.

The last column in the general Table, contains the specific gravities of a large part of the soils; that is, their weight as compared with distilled water. In general it will be seen that the most sandy soils are the heaviest; those containing the most geine, the lightest. In the absence of a better method, this character might be employed to determine the amount of organic matter in a soil. But to obtain the specific gravities of soils, cannot be regarded as a matter of much importance; though the results may be of value in the researches of the chemist.

Theoretical Characteristics of the different geological varieties of Soils.

Knowing what simple minerals constitute the different rocks, and what is the composition of those minerals, we can predict what ingredients will exist, and what ones will predominate, in the soils derived from those rocks. Where a soil is derived from quartz rock, or siliceous sandstone, we should expect that silica would greatly predominate, but where argillaceous slate forms the foundation of the soil, alumina will abound. We should expect a large proportion of lime in soils underlaid by limestone: though from causes already explained, analysis does not always verify this anticipation. In soils derived from granite, gneiss, mica slate and those sandstones abounding in fragments of feldspar and mica, we might expect to find potassa, or its salts, because this substance abounds in those minerals. In porphyry soils, for the same reason, soda might be expected: also magnesia in talcose slate soils:

and the single analysis of such a soil by fusion, given on a previous page, corresponds to this prediction. Since iron abounds in all the rocks, we should not expect beforehand to find it peculiarly abundant in any variety of soil.

As to the existence or predominance of silica, alumina, iron, lime and magnesia, in a soil, analysis, as already pointed out, will enable us to determine this point; and, indeed, in respect to most of these ingredients, mere inspection is sufficient for all practical purposes: and from the tables of analyses that have been given, these characteristics, as they exist in the soils of Massachusetts, can easily be determined. But in respect to the alkalies, potassa and soda, which unquestionably exert an important influence upon vegetation where they exist, the case is quite different. As these exist in the feldspar and mica of soils, they are perfectly insoluble in water, but when set free by decomposition, even though converted into salts, they become easily soluble in water: and the consequence is, that rains soon carry them away. We should hence expect the chemist would rarely find them, even in traces. But as some chemists are of opinion that the salts of the alkalies do exist, widely disseminated in soils, I felt desirous of settling the point in relation to the soils of Massachusetts. I selected specimens of nearly every variety of soil in the Government collection, and having boiled 200 or 300 grains for several hours in snow water, until the quantity was rather small, I filtered; and to the solution added a small quantity of a solution of nut-galls. Had there been the minutest quantity of alkali present, the solution would have assumed a greenish tinge: but in no instance was this the case. Hence I infer the absence of alkali, and of alkaline salts. The soils thus tested were Nos. 9, 14, 29, 48, 62, 71, 82, 110, 121, and 124.

From such facts, however, I do not infer the absence of potassa and soda in every form from our soils; but only in a soluble state. On the other hand, it is almost certain, that in many of our soils they must exist in considerable quantity, and I doubt not but they exert an important influence upon cultivation. I impute the productiveness of many of our gneiss, granite, and sienite soils, to these substances. But I am inclined to adopt the opinion of Dr. Dana; who supposes that the rootlets of plants, by means of galvanic agency, have the power to extract alkali from the particles of feldspar and mica in the soil.

If these views are correct, it follows that it can be of little importance for the chemist to determine the precise amount of potassa or soda that may exist in the undecomposed feldspar or mica of a soil. For if the soil have resulted from the disintegration of rock that contains feldspar, he may be sure that alkali is present: But whether it will be of any use:—that is, whether it can be extracted from the soil by the plants, will depend upon the degree of comminution in the soil, and probably upon other circum-

stances not yet fully understood. That such salts as the sulphate of potassa may be found in some peculiar soils, is very probable; and their detection by analysis would be important; but with my present views, I anticipate that the search for them in the soils of New England generally will be in vain.

Such considerations cannot but lead the chemist to enquire, whether other principles, as important as the alkalies, may not exist in soils in such a state that they escape the notice of the analyst; or which he cannot detect in such a state as to afford much aid to practical agriculture. If so, perhaps it may partly explain why careful analysis has accomplished less for agriculture than had been anticipated; and that such is the fact, I am compelled to admit. I do not mean that analysis has been of no service to the farmer. In some instances it has pointed out to him particular substances in his land, that were beneficial or injurious; of which he would otherwise have been ignorant; and in all cases analyses form important materials for improving the theory of agricultural chemistry: which is certainly yet far from perfect. But probably some have been led to suppose, that the chemist, by analyzing their soil, would be able at once to inform them what ingredient might be added to insure fertility. This would imply a degree of perfection in agricultural chemistry to which I think the science cannot yet lay claim. To be sure, the analyst can often suggest the application of ingredients which will probably be beneficial. But the causes on which the growth of plants depends are too complicated, and as yet too imperfectly understood, to permit his recommendations to be infallible. And this leads me to express the opinion, that were a chemist to be employed in making experiments upon the manner in which geine and the salts in soils are taken up by vegetation; as well as upon the best mode of converting soluble into insoluble geine; and to analyze plants in their different stages of growth; very important results might reasonably be expected. The experiments which the farmer makes, that bear upon these points, (and a multitude of such experiments are made every year,) are performed as it were at random, without those fixed principles to guide him, which an accurate knowledge of chemistry would furnish; and hence it is only as it were by chance that any useful results follow.

General Conclusions.

Having as I hope, by the preceding remarks, prevented the indulgence of unreasonable expectations from the examinations which I have made of the soils of Massachusetts, I proceed to state the most important conclusions to which those investigations have conducted me.

First: there is in general too small a supply of calcareous matter in our soils: that is, of lime.

The second great desideratum is an additional supply of geine, or the food of plants.

Hence, thirdly, the great object of the agricultural chemist should be, to discover new supplies of both these substances; and to suggest means for their proper and successful application by the farmer.

These conclusions early forced themselves upon my attention; and all my subsequent researches have served to confirm them. Hence, therefore, I made it my constant endeavor, to discover and examine the character and extent of every deposite that would yield either geine or calcareous matter. I shall now proceed to give the results of my efforts. I shall begin with lime. For although it cannot perhaps be regarded so important as geine, yet in common manures, the farmer possesses a store of the latter, which he knows how to apply. But with the exception of Berkshire County, Massachusetts is very deficient in calcareous matter: and the few spots where it may be found have as yet scarcely begun to excite any attention.

I. CALCAREOUS MATTER IN MASSACHUSETTS.

1. *Marls.*

No form of calcareous matter is so valuable in agriculture as rich marl. This term, however, has been till recently very loosely applied; often meaning nothing more than loose clay, entirely destitute of lime. But all accurate writers now understand it to mean a friable mixture of lime and clay; although the term is extended to beds of calcareous shells that are somewhat hard. Till within a few years, this substance has been neglected in our country; but its remarkable effects in some of our middle and southern states, have awakened the public attention; and it is now sought after with no small avidity. From the nature of our rocks, I had no hope of finding rich marls in any other part of the State, except the County of Berkshire. From that part of the State, many years ago, I had seen a specimen that appeared very rich. I prepared therefore to go in search of the bed from which it was taken; and by the directions of Professor Dewey, I found it in Pittsfield, near the east part of the village, on the borders and in the bottom of a pond covering several acres. It seemed to me very probable that similar beds must occur in other parts of that County where limestone prevails. My search was soon rewarded by the discovery of an extensive bed in the northwest part of Stockbridge on land of Mr. Buck; whose thickness was about

two and a half feet, and probable extent, very great. Also a second bed in the same town, only four miles from the court-house in Lenox. Also a third bed in the northeast part of Lee, at the Mills of Sedgwick and Co., the thickness of which, in some places, is about ten feet; though its extent is but a few acres. Also, several beds in West Stockbridge in various parts of the town. The limited time which I gave to these researches did not allow me to make but slight examinations in other towns. But I have little doubt that similar beds of marl will be found in various other places in the County; especially in Sheffield, Great Barrington, Egremont, Alford, Richmond, Lanesborough, New Ashford, and perhaps in Williamstown, Adams, Cheshire, Dalton, and New Marlborough. I am confirmed in this opinion from the fact that since I visited the County several other beds have been discovered.

A second bed has been found in Pittsfield, about a mile south-east of the village. Also a bed in Stockbridge, a little northeast of the village on the road to Lenox. For specimens from both which places, I am indebted to Professor Dewey. A third bed has been found covering several acres in the north-west part of Lee, near a pond, on land of Messrs. Lemuel and Cornelius Bassett. The thickness of the marl, which commences about a foot below the surface, is in some places from four to seven feet, and in others, from ten to twelve feet; and from 200 to 300 loads have been taken from it by the Messrs. Bassett. Specimens from all the beds that have been described will be found in the collection accompanying this Report. (See Nos. 148, 149, 150, 151, 152, 153, 172, 173, 174, 175.) I am informed also, that a small bed exists in Tyringham, and another in Sheffield, and two at least occur in Great Barrington.

The purest of these marls when dry, are almost as white as chalk, and much lighter than common soil, as may be seen from the specific gravities of a part of them in the table of their analysis below. When wet they are of a light gray color, especially if they contain much organic and earthy matter: indeed the degree of their whiteness is no bad index of the quantity of lime that they contain. When wet they are quite plastic and adhesive: when dry, they fall into a fine powder. Hence they are in a most favorable state for being spread upon land. They are found almost exclusively in swampy ground, generally in quite wet swamps, and are always covered by a stratum, often several feet thick, of black vegetable matter approaching to peat. Hence, as these swamps are rarely excavated, the marl is not apt to be discovered; or if found, it is supposed to be nothing more than white clay and sand, which, indeed, it does very much resemble. In order to ascertain the presence of marl in a swamp, I prepared an iron rod, several feet long, near the end of which was a grove, in fact it formed a sort of auger. When pressed into the ground and withdrawn, it would always retain in the groove

some of the matter from the bottom of the hole, and in this way, in a few minutes, not only the existence of marl might be ascertained, but the thickness of the bed. Yet after all, since the swamps where it occurs are usually very wet, and easily penetrated, a rough pole is better for discovering marl and its thickness, than the iron borer which I have described. For some of it will adhere to a pole plunged into it, even though that pole must be drawn through several feet of vegetable mud above it. And if the pole be plunged to the bottom of the bed, the distance along the pole covered with marl, will show the thickness of the bed; except that the lower extremity of the pole will show beneath the layer of marl the clay or sand as far as they were penetrated: and this extent must be subtracted from the whole length covered with marl. I have been thus particular in describing the method of searching for marls, in the confidence that if gentlemen residing in the towns above mentioned will adopt it, many new beds will be brought to light.

There is a substance in the central and eastern parts of the State, in exactly the same situation as the marl of Berkshire, which resembles it also very precisely in external characters, and is also like marl very light; and yet it is not marl. It does not contain carbonate of lime, but is composed chiefly of silica. Specimens of it will be found in the collection from several places. (See No. 157, which is from Spencer; No. 169, from Barre, and No. 170, from Andover.) It is easy, notwithstanding its general resemblance, to distinguish it from marl by a few drops of vinegar, oil of vitriol, aqua fortis, or any other acid. If a substance be marl, the acid will produce in it small bubbles occasioned by the escape of gas—if not marl, no effervescence will be produced. And this is a universal test, which is almost infallible, for distinguishing marl in all circumstances.

One other circumstance respecting the Berkshire marl, which will aid in distinguishing it. It abounds every where with small fresh water shells, such as now occur in the ponds of that region, and therefore it is unquestionably true fresh water marl, usually called shell marl. The epidermis of the shell is usually gone. Such shells are rarely found in much quantity where lime does not exist, although I have seen them in mud that did not effervesce. But their presence should lead us to search carefully for calcareous matter: for how can these animals form their shells without lime?

The Berkshire marls, above described, appear to me to be some of the richest and best that ever occur. Marls are usually valued only for the calcareous matter which they contain. But by adopting Dr. Dana's method of analysis, we find that they also contain no small quantity of soluble and insoluble geine, derived from the vegetable matter that covers them. This must make them still more valuable when applied to the soil. They contain likewise a small portion of phosphate of lime, increasing their value still

more: while the silicates in them, the only part that is of no value, are in most cases extremely small. The following are the results of the analysis of the specimens in the Government collection.

I have added the analysis of a specimen of similar marl from Farmington in Connecticut, for which I am indebted to Professor Silliman. For the geological character of Farmington and the surrounding region is very much like that of Springfield and West Springfield; and therefore I cannot but hope that some of the swamps in the latter places may contain it. The bed in Farmington is said to be extensive.

Marl of this description is usually supposed to result wholly from the decomposition of minute fresh water shells: But since it is not unusual for water in limestone to contain a small quantity of carbonate of lime in solution, by means of free carbonic acid, it seems to me that the deposition of this carbonate of lime in a pulverulent state, in consequence of the escape of the acid, is the probable origin of a large part of the marl.

No.	LOCALITY.	Soluble Geine.	Insoluble Geine.	Phosphate of Lime.	Carbonate of Lime.	Carbonate of Magnesia.	Silicates.	Water of Absorption.	Specific Gravity.	REMARKS.
148	Stockbridge, (Mr. Buck's Farm,)	4.3	4.6	0 7	73.4	0.15	13.5	3.3	1.82	2 1-2 feet thick.
151	do northeast of the village,	5.0	8.9	0.6	46.0	trace.	36 6	2.9		
203	do do - - - -	0.6	3.8	0.8	31.8		59.8	1.7		1.5 Sulphate of Lime: Specimen from another part of the bed.
149	Pittsfield, east of the village,	3.1	3.5	0.7	86.4	0.46	3.1	3.0	1.82	4 feet thick at least.
152	do S. W of village (Mr. Strong's lot,) - - - - -	3.1	3.2	0.4	64.8	trace.	25.2	1.9		
150	West Stockbridge, Mr. Reed's land,) - - - -	7	5.0	0.5	74·8	0.53	14.7	2.8	1.61	
153	Lee, Sedgwick & Co's mills,)	.2	2.1	.0	93.2	no trial	0.9	1.6	1.89	Exposed to the action of running water.
172	do (L. Basset's bed, near the surface,) - - -	.8	2.2	1.4	93.0	do	2.2	0.4		9 to 12 feet thick.
173	do do 10 feet below the surface, - - - -	.6	2.8	.0	88.8	do	4.4	1.4	1.75	
174	do (C. Bassett's bed,) - -	2.6	3.4	1.2	86.2	do	5.0	1.6		Nos. 172, 173 and 174 are from the same bed.
175	do (Sedgwick's mills,) - -	0.8	4 4	0	83 6	do	9.2	1.0		Not Exposed to the action of running water.
204	Farmington, Ct. - - -	3.0	9.5	0.4	64.4	do	17.8	2.9		2.0 Sulphate of lime. No trial for the sulphate in the other specimens.

The amount of calcareous matter in these marls is unusually large, with the exception of one of the specimens from Pittsfield, and another from the east part of Stockbridge. And these specimens were not taken directly from the beds, but as they had been thrown out in making excavations; and the marl was obviously mixed with loam and sand; so that the quantity of carbonate of lime by the analysis is doubtless too small.

Again, most marls are only in part pulverulent, or easily crumbled down, and they require a long time after being mixed with the soil, before they will exert a favorable action upon it. But these are all in a state best adapted for immediate use; and when we add to these considerations those already made concerning the other ingredients of these marls, I cannot but feel that Berkshire possesses in them a very great treasure. I doubt not but an inexhaustable supply may be found there, not only for the county but for exportation. And since the most numerous beds yet discovered occur very near the point (West Stockbridge) where two great rail roads are soon to intersect, I cannot doubt that this marl will be among the articles of export at least a considerable distance. The marls of New Jersey and Virginia, it is well known, are already beginning to be transported a great distance. And if any marls are rich enough to be thus conveyed by land or water, surely those of Berkshire must be of the number. It will doubtless require a long time to satisfy many of our farmers of the value of marl: and especially as we may expect many failures from applying this marl in improper quantity, or in the neglect of collateral circumstances essential to success. But unless a vast amount of experience in the use of marl in Europe and in this country is to be set aside as a ground of judgment, these marls must sooner or later work an important improvement in a portion of the agriculture of this State.

There is an important fact derived from the analysis of soils that have been given, relative to the character of those in Berkshire county. It had formerly been supposed, that the soils of that county contain so much lime that marls would be of no service there. But it appears that they contain scarcely any more of this substance, either in the form of carbonate, sulphate, or phosphate, than the other soils of the state. At least, the specimens analyzed do not; and these were taken at random from fields underlaid by limestone; so that probably they show about the average quantity of lime in the soils of the county; though I doubt not that soils may be found there containing more of this substance. I think this may be a safe rule to follow by the farmers of that county. If a soil effervesces with vinegar, or other acids, they may infer that marl will be of little service. If it do not effervesce, they may safely apply marl. And judged of by this rule, I doubt not that four out of five of the Berkshire soils will be found to need it. It ought to be expected, however, that this rule will sometimes fail; because a soil may contain lime in some other form than the carbonates, so that for several years the marl may do no good.

In what Quantity and Mode shall Marl be applied?

I do not conceive that it falls within the sphere of duties assigned me by the government, to go into details respecting the mode and the quantity in which marl shall be applied, except so far as these questions can be answered by agricultural chemistry. It is well known that, in many instances, lands have been injured by over marling; and hence one is met everywhere with the questions above suggested. And certain it is, that no general rules have thus far been followed or proposed. Nor can we get any general rules on the subject until the manner in which lime acts upon soils and vegetation is understood. Here, it must be confessed, great confusion and a variety of opinions have prevailed. The action of lime is undoubtedly quite complex, and considerably different on different soils; which renders any general theory more difficult. The doctrines respecting geine, which have been explained, appear to throw more light on this subject than has ever before shone upon it; though some points still remain obscure; and as Dr. Dana has obligingly furnished me with his views on the subject, I shall present them without hazarding any opinion of my own; except to say, that his theory is manifestly in advance of any that has hitherto appeared.

Theory of the action of Lime on Soils, Manure, and Vegetation.

" The action of lime is threefold; each distinct. 1. It is a *Neutralizer:* 2 a *Decomposer:* 3. a *Converter*. 1. I have already alluded to some acid soils: free phosphoric acid, geic, acetic, and malic acids, also occasionally exist in a free state in soils. Here lime acts as a neutralizer.

2. Soils may contain abundant geates; particularly geate of alumina, the least of all demanded by plants. Long formed and sun-baked, they are scarcely acted on by rain or dew, and are almost useless. Here lime, by decomposing these metallic and earthy geates, forms a combination, which, in its nascent state, is readily dissolved. If the carbonate of lime acts better than the hydrate, it is because, following a well known law, double decomposition is easier than single. If any acid geine exists in the soil, or any free acids, carbonic acid is then liberated; it acts on the geate of lime, supergeates result, and these are easily soluble."

"3. The great use of lime is as a *converter*; turning solid and insoluble geine, nay, I go further, solid vegetable fibre, into soluble vegetable food. Here is the great puzzle, the point where our philosophy seems to leave us: giving us our choice, to refer this action to one of the numerous cases of mysterious '*catalytic*' change, with which we are becoming every day more and more familiar, or to explain the process by referring the whole to *saponification*. I use this word as conveying to you at once what I mean;—but I do not mean to say that the product of lime and vegetable matter is soap; but I cannot make myself more intelligible to a farmer than by saying, this lime makes compounds of vegetable matter, just as it makes soapy compounds of oil and fat. The action of lime on geine I take to be of the same nature, as its action on oils and fat. It is well established that animal and vegetable oils and fats are converted into acids by the action of alkalies, earths, oxides, and even by vegetable fibre itself. The general law is, that whenever a substance, capable of uniting with the acid of fat or oil, is placed in contact with fat or oil, it determines the production of acid. Now we have seen that alkali produces a similar change on geine; it developes acid properties. I go further, if alkali has converted vegetable oil and geine into acids, I see no reason why a similar action may not be produced by all those substances which act thus on oil. Hence *lime*, earths, and metallic oxides, convert geine into acid: as fast as this takes place, so fast it becomes soluble. Then too the long action of air on insoluble geine, rendering it soluble, is it not analogous

to the action of air on oils. Both evolve in this case, vast volumes of carbonic acid, the oil becomes gelatinous and soluble in alkali; does not a similar change occur in geine? It is possible that during the action of lime on geine, a soluble substance may be produced, bearing the same relation to this process that glycerine does to saponification. These views you will see need to be followed out experimentally. If found tenable, the most signal benefit will result. We place manures on a new foundation, on which great practical results may be erected."

Practical application of the Theory of the action of Lime.

Taking the preceeding principles by Dr. Dana as our guide, we may lay down a few general rules for the application of marls.

1. Enough ought to be applied to neutralize all the free acids in a soil; which may be known by its ceasing to produce acid plants, such as sorrel and pine. Generally, however, the amount required for this purpose is small.

2. It will be serviceable to add enough to convert the earthy geates of a soil into geate of lime. The richer a soil is, the greater we may conclude is the quantity of geates which it contains.

3. It will be serviceable to add enough to convert all the insoluble geine and vegetable fibre in a soil into soluble geine. Hence the richer a soil is, and the more manure is added, the more marl will it bear with benefit. Indeed, *there appears to be no danger of adding too much marl, provided a sufficient quantity of manure be also added.* Ignorance of this principle, I apprehend, is the source of most of the failures that have occured in the use of lime upon soils. Farmers have supposed that its action was like that of common manure, viz., to serve as direct nourishment to the plant; whereas it only *cooks the food,* if I may be allowed the expression, which exists in the soil, or is added along with the lime. In nearly all cases of over marling which I have read of, a fresh supply of manure has been found to be the remedy; which shows the truth of the above principle. Agriculturalists have spread marl alone, or with very little manure, upon land that has been worn out, that is, whose geine has been exhausted; and because such soils have not thereby been recruited, they have inferred that lime was injurious. Without acids, or geine, or geates, or vegetable fibre, to act upon, much excess of lime appears to operate injuriously, so as to diminish, instead of increasing the crop. They have also expected a sudden and surprising increase of fertility: whereas in some cases the chief benefit seems to consist in causing the land to produce for a greater number of years, by preventing the ultimate decomposition and escape of the organic matter. In general, however, it will add also to the yearly product: but those who employ marl or lime in any form, ought to moderate their expectations, that they may not be disappointed, and to be satisfied if they can slowly and surely improve their

lands as they most assuredly can do, by this substance, provided they do not expect to accomplish it by the use of lime alone.

These general rules can afford only a general guidance as to the quantity of marl proper to be used. Both marls and soils vary so much in their composition, that probably direct experiments will always be necessary to ascertain the quantity of any new variety of marl that will be most serviceable. And should any be disposed, as I doubt not they will be, to try the marls above described, I beg leave to recommend to them, as the best practical treatise that has been published in this country, on this subject, " An Essay on Calcareous Manures," by Edward Ruffin, Esq. of Virginia, Shellbanks, 1835. This gentleman has tried a vast number of experiments on the subject, and the perusal of his work is almost indispensable to any one who would successfully prosecute it. He says, "if the nature of the soil, its condition and treatment, and the strength of the marl were all known, it would be easy to direct the amount of a suitable dressing: but without knowing these circumstances, it would be safest to give 250 or 300 bushels to the acre of worn acid soils, and at least twice as much to newly cleared, or well manured land." (Essay pp. 54.)

As to the best mode of applying marl, theory would lead us in general to prefer the method usually adopted, viz: to mix it with compost before spreading it on the soil. And I would here express a hope, that if experiments are made on the Berkshire marls, a portion of the black vegetable matter that lies above them, may sometimes be mixed with them, to see whether it may not become converted into a geate, and thus increase the value of the marl. It would indeed be an important discovery, if from the same swamp both the geine and the lime could be obtained, in a state proper to sustain vegetation.

In a few instances the Berkshire marl has been tried upon cultivated land. In the North part of Stockbridge, several years ago, Mr. Hadsel Buck spread 40 loads from the bed on his farm upon a field of grass, and he describes the effect as excellent. A mile or two east of this spot Capt. Enos Smith, many years ago, took a quantity from another bed and spread it upon grass ground with very marked benefit. It has also been tried in Pittsfield, by Samuel A. Danforth, Esq with encouraging success.*

The agricultural surveyor of Massachusetts, in his Second annual report, has mentioned a few recent trials with these marls that have not proved so successful. In one instance, that in Sheffield, it was spread alone upon a wheat field, and no apparent effect was produced. I should not expect any effect from such an experiment, especially the first year: for probably this mode of applying it is one of the poorest: and secondly, in Europe "it is well known that lime produces scarcely any sensible effect as a manure at the beginning. Even the first year after it is applied to the soil its effects are inconsiderable, in comparison of what it produces in the second and succeeding years" (*Morton on Soils p.* 177) And finally for aught that appears, the soil may already contain all the lime immediately necessary: for it is based upon limestone. In the other case, a shovel full of marl was put into each hill of potatoes, and although the crop appeared better early in the season, it was not so superior at the time of harvest. In this case the quantity of marl used was much too large; according to any rules that I have ever seen laid down.

Now in my report of 1838 I predicted such results as these: and I shall expect more of them before the best mode of applying the Berkshire marl shall be discovered. Nor would it be

* I feel under great obligations to Hon. Judge Walker, and H. W. Bishop, Esq. of Lenox, for their attention and assistance in searching for beds of marl in that vicinity. Also to Charles B. Boynton, Esq. of West Stockbridge. To Sedgwick & Co. and Mr. Lemuel Basset, I am indebted for the specimens from their marl beds in the government collection. I might name several other gentlemen in that county who have given me much assistance.

strange if many should hence become entirely sceptical as to the value of this substance, and give up further experiments with it. But how unphilosophical to set a few unsuccessful but imperfect experiments, continued only a year or two, against thousands of successful experiments made in Europe and in our own country for a great number of years! I am not, however, commissioned to try experiments with these marls, but to point them out to others. And I pledge myself, that they are precisely of the same nature, and as rich in calcareous matter, as those which in other parts of the world have produced most valuable effects upon agriculture. And I have little doubt, but if the present generation do not derive similar benefit from them, posterity will.

I have supposed that the discovery of earthy substances containing a much less quantity of calcareous matter than the marl that has just been described, might be of great benefit to agriculture in a region so destitute of lime as Massachusetts in general. Accordingly, I have examined our clays and diluvial deposites with reference to this point and shall now give the result of my researches.

2. *Marly Clay.*

The clays of Massachusetts are in general destitute of carbonate of lime, except that they sometimes contain remarkable concretions called ***clay stones***, which usually consist of about 50 per cent. of this substance. In a few instances, however, I have discovered beds that contain a few per cent. of carbonate of lime; not enough to bring them under the denomination of marl; yet in sufficient quantity to make them objects of interest in agriculture. For as will be shown in another place, clay alone often exerts a very favorable influence upon land; much more probably, when it is united with calcareous matter. The following table exhibits the composition of all the beds of marly clay which I have discovered; analyzed by fusion with carbonate of soda in the usual way: after extracting the carbonate of lime by an acid.

No.	Locality.	Silica.	Alumina.	Protoxide of Iron.	Carbonate of Lime.	Lime.	Magnesia.	Water of Absorption.	Loss.
146	Williamstown	60.24	15.53	7.57	11.7	0.12	1.86	2.3	0.68
147	North Adams,	59.07	5.49	4.28	28.0	trace	1.59	0.7	0.87
219	South Lee,	51.79	21.47	7.89	12.2	do	2.02	2.8	1.83
206	Springfield,	64.81	14.40	5.30	7.6	do	2.36	3.8	1.73

The specimen from North Adams, where it occurs a little east of the village, in an excavation for making brick, ought rather to be called calcareous sand, than marly clay: as will be obvious by inspecting it.—That from Springfield was obtained in boring beneath Connecticut river under the direction of Major Whistler, the engineer on the Western Rail Road: to whom, and to Capt. Swift, I am indebted for specimens and a Section which will be more fully described in the scientific part of my report. The

clay on the banks of the river, so far as I have examined, does not effervesce: yet this point, which is one of great importance, needs farther examination. The specimen from South Lee was obtained from a clay bed on land of Mr. Merrill, a mile and a half east of the village, on the Housatonic river. Research, I have no doubt, will bring to light other beds, especially in Berkshire county: and I should not think it strange if this substance should prove more immediately beneficial upon the soil, than the rich marls that have been described.

3. *Peculiar Calcareous Soil.*

In passing from South Lee to Stockbridge, a very peculiar limestone rock may be seen, although from its dark color it is not usually supposed to be limestone. It is indeed very impure, and will never be used either for burning into quicklime or for marble. Yet by decomposition it produces a peculiar reddish soil, which appears not only to be very fertile, but I apprehend may be employed advantageously to spread upon other soils. My attention was drawn to it, by the fact that it has been so employed to some extent upon gardens in Stockbridge. And as this rock may probably be found more or less abundantly, nearly all the way from Stockbridge to the north line of the state, I thought the soil resulting from it deserved an analysis. The specimen made use of, (No. 139,) was obtained near a ledge of this limestone, a little east of the village of Stockbridge, and yielded the following results.

Water of Absorption,	3.80
Soluble Geine,	0.93
Insoluble Geine,	1.99
Carbonate of Lime,	30.57
Sulphate of lime,	1.40
Phosphate of Lime,	1.63
Lime,	0.09
Silica,	46.43
Alumina	6.82
Peroxide of Iron,	4.01
Magnesia,	1.03
Loss,	1.30
	100.00

A glance at the preceding analysis lets us at once into the secret of the fertilizing properties of this peculiar soil. For to say nothing of the geine, whose quantity is small, the salts of lime, which it contains, must make it valuble as a manure. And as to the iron, I am inclined to believe that it exists in the rock originally as a carbonate: though I have not ascertained this experimentally. But if such be the case, the carbonic acid which escapes, as the oxide of iron is evolved, will probably be seized by the organs

of growing plants. Does not this substance demand the attention of Berkshire farmers? If it can be found of the character of that analyzed in considerable quantity, it can hardly fail of being a valuable means of improving much of their land.

In addition to the good effects of this calcareous substance upon soil, which I have mentioned, as shown in Stockbridge, I would refer to a district in Adams, where the soil is highly impregnated with it. The eastern part of Saddle Mountain has a valley running nearly north and south, and rising very high at its southern extremity, called the Tunnel. I was surprized to find in this valley some of the best dairy farms in the county; and even at its southern extremity, which cannot be less than 1200 feet above the villages in Adams, the luxuriance of the grass I have hardly seen excelled any where in the state. On examining the soil, I found it to be highly charged with the peculiar compound under consideration, derived from the bastard limestone which runs through the valley, and whose gradual decomposition not unlikely may have formed the valley. An analysis of this soil is given on a preceding page: (No. 192, p. 42.) from which it seems that the carbonate of lime is almost exhausted, and that it possesses no other remarkable characters. But in the facts above developed, I doubt not we have the secret of its unusual fertility.

4. *Calcareous Diluvium.*

In the red sandstone of the valley of Connecticut river, beds of fetid limestone occasionally occur: and besides, in the towns of Springfield, West Springfield, and South Hadley, the red slaty rock contains a few per cent. of carbonate of lime. In early times this rock has been extensively worn away, and the small fragments and fine sand or clay, thence resulting, have been piled up over the greater part of those towns. This accumulation of detrital matter, I call *diluvium;* and on applying acids to it, in very many places in the towns above named, I found it strongly to effervesce, especially when dug from a little depth. The lime serves as a cement, so that in most places it is almost as hard as a solid rock, and requires a good deal of labor to get it up. But exposed to wet, heat, and cold, it at length crumbles down, and becomes fit to spread upon land; although the size of the pebbles often might injure grass fields, unless they were separated by means of a riddle. Since this diluvium was deposited, a thick layer, first of clay, and above this, of sand, has been brought over most of the region, so that the diluvium appears only in those places where the sand and clay have been worn away. But it occurs so often that it is accessible in a multitude of places. I will mention the banks of Agawam river, a little west, and also south, of the village of West Spring-

field; also at the south end of the village of Springfield, in several places along the banks of the small river on which stand the lower "Water Shops." In one spot on the north bank, is an elevation belonging to the United States' Government, which ten years ago was nothing, but a barren sand hill. A large quantity of this diluvium, and of the disintegrating slaty rock beneath it, was carted upon this spot, and not only has it fixed the sand, but produced a coating of clover, grass, and young locust bushes. I was there informed, that near the same spot, six or eight years ago, some of this diluvium was put upon a small sandy ploughed field, and that the good effects are still visible. In another case eight years ago, some of it was mixed with a small quantity of hog manure, and the land still produces better crops. The testimony here, and also at Chicopee Factory Village, as well as in West Springfield, was, that wherever this diluvium is spread, clover soon makes its appearance; a result almost uniformly attending the judicious application of marl.

In the banks of Chicopee river, in numerous places from its mouth nearly to Putt's Bridge, thick deposites of this diluvium appear. An enormous bed of it exists on the east bank of Connecticut river, a little south of the village at South Hadley Canal. It occurs, also, in abundance, a little south of the village of South Hadley. I have searched in vain for it in other parts of the valley of the Connecticut. No where else in Massachusetts does the red sandstone appear to contain enough of carbonate of lime to make its detritus sensibly calcareous. And although I have been told, on good authority, that in the vicinity of Hartford and Middletown, Ct., the diluvium does effervesce with acids, yet after repeated trials in various places from Massachusetts to Middletown, I have not found any that was sensibly calcareous. At present, therefore, I must consider this variety confined to the three towns above named: though I doubt not that I might safely add Longmeadow and Wilbraham. I have analysed only three specimens; but these probably will give us about the average amount of carbonate of lime. The specimens analyzed will be found in the state collection.

No.	Carbonate of Lime.	Silica and Alumina.	Carbonate of Magnesia.	Peroxide of Iron.	Water of Absorption.	Locality.
154	6.3	80.0	slight precip.	12.4	2.3	Chicopee Factory, Springfield.
155	4.8	83.2	slight precip.	11.0	1.0	Springfield, Lower Water Shops.
156	8.0	71.6	0.4	19.0	1.0	West Springfield.

The amount of calcareous matter in this diluvium appears small, when compared with that in the Berkshire marls. And I presume it will not be found valuable enough as a manure to be transported a great distance. But

it ought to be recollected, that it needs only a small quantity of lime in a soil to work wonders upon vegetation. And further, it happens that in the immediate vicinity of nearly every bed of this substance, is a great deal of that sterile sandy land, which most needs a coating of marly clay, which is in fact the character of the calcareous diluvium. The large quantity of peroxide of iron which it contains, will probably also be useful on such a soil. And where this substance can be carted directly upon such fields, I cannot doubt, but they might be made permanently fertile without great expense. I trust that some of the farmers in the vicinity of this diluvium, will at least be tempted to try a few square rods of sandy land in this manner; and then they can judge whether its more extensive application may not be profitable. Who knows, but this substance, which has hitherto been regarded as a sign of utter barrenness, and employed only for mending roads, may at some future day spread fertility over many a field now scarcely worth cultivation!

I ought to remark, that in many places, beds of this diluvium occur which contain little or no calcareous matter, because the rocks from which they were derived, contain none. Hence in using this substance upon soils, none ought to be employed which does not effervesce with vinegar, or other acids. By omitting this precaution, an experiment may fail, which would otherwise succeed.

5. *Limestone.*

Upon the whole no rock is so important in an economical point of view as limestone; and no part of the world is better supplied with this material than the western part of Massachusetts. Enough exists to furnish the whole state, and I might say probably with truth, the whole of New England, through all future generations with marble and quicklime, were it spread through the country. But in other parts of the state limestone is comparatively rare; and I have searched for it with more diligence than for almost any other substance. The numerous small beds which I have discovered, lead me to hope that I have not labored altogether in vain. I shall now present a table of the analysis of nearly every deposite which I have found out of Berkshire county; and of several of the most important localities in that county. The more common limestones there I have neglected; because they will never probably be used. But inferior varieties will be valuable in other parts of the state; and therefore, I have analyzed all which I have discovered.

I have reduced all the following analyses to a centesimal standard: and although there was always a small loss in the process, I have neglected it; because in a practical point of view it can be of no importance, and would somewhat embarrass any one not conversant with chemical processes, who wishes at a glance to determine the composition of our limestones.

The numbers in the first column refer to those in the State Collection. I have added also a column of specific gravities; although this item can be of no great importance.

I am inclined to believe that in most of the limestones of Massachusetts, the iron exists in the state of a carbonate: And such a supposition accords rather better with my analyses than to suppose it in the state of peroxide. But as the quantity of iron is in most cases very small, and the difference as to amount between the carbonate and peroxide is slight, it is not easy to determine whether a loss so small as that difference is to be imputed to errors of analysis, or to the escape of carbonic acid: and as in the analytical process the iron must be estimated in the state of peroxide, I have put it down in the table as such. If any one wishes to reduce this to the state of carbonate, he can do it by this formula; 978 : 878 :: Peroxide : Protoxide. Then 61.44 : 100 :: Protoxide : Protocarbonate. Or Protocarbonate ÷ 1.46 = Peroxide.

No.	LOCALITY.	Carbonate of Lime.	Carbonate of Magnesia.	Peroxide of Iron.	Silica, Alumina, &c.	Specific Gravity.	Per cent. of Quick-lime.
429	North Adams, crystalline, white, - - - -	99.60		trace.	0.40	2.74	55.78
432	Lanesborough, do do - - - -	99.40		do	0.60	2.69	55.66
1901	West Stockbridge, do do Fitch's Quarry, - - -	98.10	1.16	0.14	0.60	2.67	54.94
1903	do Boynton's Quarry, do do - - - -	98.67	0.47	0.08	0.78	2.71	55.25
1905	Lanesboro' best for marble, do - - - -	96.11	2.28	0.22	1.39	2.74	53.82
1908	Boston Corner, white crystalline, - - -	87.32	1.20	0.23	11.25	2.69	48.90
1916	Hancock greyish, - do - - - -	93.38	3.56	0.57	2.49	2.67	52.29
2497	Worthington, white, do - - - -	99.85		0.15			55.92
470	Bernardston, do do - - - -	98.38		0.62	1.00	2.72	55.09
459	Whately, grey, - do - - - -	66.00			34.00	2.72	36.97
1919	do 2d Specimen, do - - - -	64.66	5.01	1.54	28.79		36.21
463	Southampton, grey, do - - - -	38.40			61.60	2.93	21.50
494	Walpole, do do - - - -	70.30			29.70	2.80	39.37
1910	Attleborough, do compact, - - - -	94.60			5.40	2.71	52.98
2503	Norwich, do micaceous, - - - -	53.80			46.20	2.79	30.13
1907	Sheffield, white crystalline, Girard College Quarry, - - -	97.80			2.20	2.75	54.77
1906	Egremont, white, crystalline, - - -	92.80	1.20		6.00	2.69	51.97
436	Sheffield, dolomitic granular, - - - -	58.04	40.40		1.20	2.84	32.70
1925	do do marble, - - - -	54.87	40.61	0.38	4.14	2.83	30.73
437	Lanesborough, Gray Marble, - - - -	93.60	5.50	0.60	0.30	2.76	52.42
433	New Ashford, Flexible marble, - - - -	81.80	16.20	0.60	1.40	2.68	45.81
1927	New Marlborough, Dolomitic, Capt. Smith's Kiln, - - -	54.24	44.28	0.59	0.89	2.81	30.37
1933	do crystalline, dolomitic, Hadsell's Quarry. - - - -	55.45	42.76	0.86	0.93	2.88	31.05
1924	Tyringham, South Part, Crystalline Magnesian, - - - -	54.34	44.24	0.67	0.75	2.77	30.43
1931	Tyringham, N. W. Part, Magnesian, - -	61.88	33.56	0.46	4.10	2.82	34.65
1942	Becket, S. E. Part, Magnesian, - - -	58.31	28.61	1.24	11.84	2.84	32.65
447	Pittsfield, gray, fine granular, - - - -	54.60	43.92	0.55	0.93	2.86	30.57
1935	Williamstown, foot of Saddle Mt. - - -	55.79	42.96	0.47	0.78	2.79	31.14
448	do Grey, near the College, - - - -	52.31	32.79	0.74	14.16	2.82	29.29
1932	Great Barrington, clouded Marble, - - -	60.30	38.09	0.65	0.96	2.84	33.77
216	Compact Limestone, Agawam, - - -	30.81	18.33	5.53	45.33		17.25
1758	do 2d Specimen, - - - - -	26.04	13.45	6.51	54.00		14.58
1759	Argillaceous Limestone, Agawam, - - -	55.16	22.21	7.07	15.56		30.89
1920	Micaceous do Ashfield, - - -	46.85	1.60	1,55	50.00		26.24
1921	do do do 2d Specimen, -	45.13	3.50	2.70	48.67		25.37

No.	LOCALITY.	Carbonate of Lime.	Carbonate of Magnesia.	Peroxide of Iron.	Silica, Alumina, &c.	Specific Gravity.	Per cent. of Quick-lime, &c.
*	Newbury,	80.72	2.97	0.72	8.00		45.20
1934	Lanesboro' East Part, burnt for lime,	56.82	38.50	0.67	4.01	2.81	31.82
1937	Lee, 1 mile east of village, burnt for lime,	54.80	44.98	0.22		2.77	32.88
1938	Dalton, near the village,	56.58	43.07	0.35		2.86	31.68
485	Bolton, quarry, crystalline,	61.80	27.00		1.20	2.80	34.61
491	Chelmsford Quarry, do	56.52	39.38	0.90	3.20	2.85	31.65
496	Stoneham, white compact,	59.28	15.71	1.21	23.80	2.84	33.19
211	W. Springfield gray, fetid. Paine's Quarry,	93.48	0.90		5.60	2.73	52.35
1764	Springfield, Chicopee Compact Septaria,	46.06	27.35	5.62	20.97	2.74	25.79
1757	do do fetid, gray,	86.80			13.20	2.73	48.61
1763	do Cabotville, Septaria,	43.69	39.35	3.39	13.57		24.47
1941	Middlefield, Cole's Brook, white,	56.25	31.56	1.12	11.07	2.78	31.50
1939	do a mile east of do do	88.02	9.91	0.15	1.92	2.71	49.29
478	Blanford, white,	51.66	39.48	0.91	7.95	2.77	28.93
490	Littleton, white crystalline,	54.70	43.35	0.51	1.46	2.87	30.63
1944	Sherburne, bowlders, white,	60.43	29.84	2.36	7.37		33.84
1918	Concord, S. W. Part, gray,	77.33	1.65	1.19	19.83		43.30
1946	West Natick, gray, crystalline,	72.10	7.50		20.40	2.75	40.38
1948	do purer specimen,	56.81	39.08	1.37	2.74		31.81
1951	do compact, yellowish, Rail Road cut,	54.20	0.60		45.20	2.68	30.35
1950	do do do purer specimen,	61.18	12.30	1.27	25.25		34.26
1592	Claystone, Hadley,	56.60			43.4		31.70
1651	do North Adams,	53.60	1.20		45.2	2.60	30.02
1647	do West Springfield,	48.40			51.6	2.68	27.10

I consider the practical inferences which I shall make from the preceding table to be more important than from any other analyses which I have executed. But in this place I shall confine myself to the agricultural value of our limestones, and defer a consideration of their use as marble and cement to more appropriate places.

Is Magnesian Limestone useful in Agriculture?

It has long passed for a settled principle that limestone abounding in magnesia is decidedly unfavorable to vegetation. But more accurate observations have led able writers to call this principle in question. Morton declares that in England, "although the soil is in general very thin on the magnesian lime, yet it is a good light soil for arable culture, and with manure produces good crops." (*Morton on Soils, p.* 80.) And Mr. Bakewell says, "I do not agree in opinion with those who regard the magnesian limestone districts as unfertile.—On the summit of Breedon Hill, in Leicestershire, I have seen a luxuriant crop of barley growing on land, that had borne a succession of twenty preceding crops without manuring. This is more deserving notice, being in an exposed and elevated situation, and upon the very hill of magnesian limestone which has been so frequently referred to by chemical writers, as

* I have reason to suppose that most of the limestone from this town is more magnesian than this specimen.

peculiarly unfavorable to vegetation. The limestone of this hill contains above 20 per cent. of magnesia.—The magnesian lime acts more powerfully in destroying undecomposed vegetable matter than common lime and its effects on land are more durable: hence it is in reality of greater value in agriculture, as a much smaller quantity will answer the same purpose." (*Bakewell's Geology, p.* 170, *and* 325.)

That a small proportion of magnesia is not injurious has always been admitted: a fact for which there is strong presumptive evidence in the existence of a small quantity of magnesia in nearly all soils. I strongly anticipate that the final conclusion on this subject will be, that land will bear less of magnesian than of common limestone: but that both are usually salutary. It is thought that generally lime is apt to injure until it has imbibed carbonic acid from the atmosphere, and is converted back into a carbonate, and it is also known that magnesia imbibes this gas more slowly than lime does; and this may be the reason why the former is more apt to do injury.

I have but one fact to state that has any bearing upon this question. It will be seen by the preceding Table, that the limestone burnt by Mr. Hadsell in New Marlboro,' is genuine dolomite; containing over 40 per cent. of magnesia. Now he informed me that some years since, he applied a large quantity of the quicklime derived from it, directly upon a piece of land with decided injury. But by subsequently applying a coat of manure, its productiveness was restored; and ever since it has been one of his best pieces of land. Such a fact seems to teach us, that a good deal of caution is necessary in the use of magnesian limestone: but it shows also, that with a proper amount of manure, it may prove a very valuable fertilizer.

Pulverized Limestone.

If it be a fact that quicklime mixed with the soil very soon returns to the state of a carbonate; that is, to its condition before burning, then it may be successfully applied without burning. Except in those cases where it is desirable that the lime should act energetically upon undecomposed organic matter, to convert it into geine, it would be better to apply it unburnt; provided it be reduced to fine powder. The chief value of burning seems in most cases to be, to bring it into that state. But this can be done mechanically; that is, by grinding; just as gypsum is universally prepared. Now much of the magnesian limestone of Berkshire county is more easily reduced to powder than that which is pure; and that would undoubtedly be the best mode of preparing that kind of limestone for agricultural purposes. But since it may be doubted whether magnesian limestone is as good for vegetation as that which is pure, probably the inhabitants of Berkshire will

not think it best to use the former; since they have enough that is pure. Yet these suggestions respecting the grinding of limestone, are not inapplicable to that part of the state. For those immense accumulations of the fragments of pure limestone, that exist at some of the marble quarries there, as at West Stockbridge and Lanesborough, may probably be best converted into powder in this manner. Or if fuel is so abundant in the vicinity that it is cheaper to burn the stone, the time is not far distant when this cannot be the case. Besides, when the contemplated rail roads are completed in that part of the State, and the value of lime in agriculture is better appreciated than it now is, I hazard the prediction, that pure limestone will be an article of transportation to those parts of the state now deficient in that material.

In the eastern parts of the state, however, where fuel is much more expensive than in Berkshire, the grinding of limestone may be an object of more importance. Several quarries there, have indeed been abandoned from the high price of fuel. But in most instances water power for pulverization is accessible. The greatest difficulty in the way that I can think of, is the great hardness of several varieties of these eastern limestones. Perhaps, however, a description of the different localities will form the basis of a better judgment on this point. I shall now give such a description; more with reference to the economical value of our limestones, than to their scientific relations; although there is usually an intimate connection between the two things. I have sought for limestone in Massachusetts with far more care and effort than for the precious metals, because I believed it to be of far more value. The following statements will show that I have not labored wholly in vain; though I could have wished for better success.

Berkshire Limestones.

In an economical point of view Berkshire county must be regarded as the principal mineral district of Massachusetts: and her limestone and iron form the principal mineral riches. Nothing can at all compete with these in any other part of the state, except perhaps the granites at Quincy and on Cape Ann. The vast amount of limestone in Berkshire may be seen by consulting the geological map. Nearly all the vallies abound with it, although it usually alternates with mica slate, or quartz rock. In many instances one travels for several miles across uninterrupted strata of limestone of good quality, either for agriculture, mortar, or marble. In short, the more familiar one becomes with the geology of the county, the more impressed he is with the inexhaustable amount of good limestone: and when we consider that these deposites lie upon the borders of a vast extent of

primitive country, stretching to the ocean on the east, where only a few scattered beds of limestone occur, we cannot doubt that those of Berkshire must prove an unfailing and increasing source of wealth as long as New England is inhabited.

It will be seen by the preceding analyses of our limestones that very many of those in Berkshire are magnesian. As a general fact I think the magnesian variety most abundant along the eastern part of the county, at the foot of Hoosac mountain; and the pure variety most abundant at the foot of the Taconic range. The mountains themselves with only a few exceptions, are composed of quartz rock or mica or talcose slates. In general, these limestones contain only a very small proportion of silica. In two examples of the magnesian variety, from Lee and Dalton, the rock perfectly dissolved in nitric acid: showing that it contained no silica. Only one other case of the kind have I met in the state; and that was a loose block found in Worthington, which was derived from Berkshire county by diluvial action. (See Table of Analyses.)

How to distinguish Magnesian Limestone.

It would be very desirable to have some test of easy application for distinguishing the magnesian from pure limestone: for sometimes in Berkshire they constitute different layers of the same bed. Unfortunately, however, none but chemical tests furnish an infallible criterion. But there are some characteristics that will enable an intelligent man to detect the most perfect varieties of magnesian limestone, called dolomite, without the trouble of analysis. One is, that the texture of this rock is less firm than that of pure limestone; so much so, indeed, that it frequently crumbles down into sand, as may be seen in some places in Sheffield, and particularly in Canaan, the town in Conneticut next south of Sheffield. Another character of the dolomite is, that it is less distinctly stratified than pure carbonate of lime. This is strikingly exhibited in the limestone of Lee, which is mostly dolomite. A third and a better character is, that when pure limestone in the state of powder is thrown into diluted nitric acid (aqua fortis) it dissolves rapidly, and with powerful effervesence; so that in a few moments, if enough acid has been added, nothing remains undissolved but the earthy residuum. Whereas dolomite dissolves slowly, and hours are often required for its complete solution. Sometimes, however, when a limestone contains only a few per cent. of magnesia, it will dissolve very rapidly at first, but it will require a long time to complete the process: from whence it is inferred that pure carbonate of lime in such cases is mixed with dolomite; which is a double salt of lime and magnesia.

In some cases, it must be confessed, that the presence of magnesia in limestone cannot be detected but by going through with a careful analysis, which requires the apparatus and ingredients of a laboratory, and which the practical chemist alone can manage.

Middlefield and Becket Limestone.

In ascending easterly the broad range of Hoosac Mountain from the valleys of Berkshire, the first beds of limestone which we meet lie in the east part of Middlefield, on the Pontoosuc turnpike; and on the line of the great Western Rail Road. The most westerly bed appears at the point where Cole's Brook empties from the north into a branch of Westfield river, on land of Gen. Mack. It is 5 or 6 rods thick, and is interposed between strata of gneiss, having a westerly dip of nearly 70°. One mile farther east, on the same branch of Westfield river, is another thick bed of limestone, of the same quality, lying between strata of gneiss, which lean a few degrees to the west. This stone often contains delicate serpentine, so intermixed as to form a beautiful verd antique marble when polished; as may be seen in Nos. 1954 and 1955. It is doubtful whether large blocks of this could be obtained: Yet as one of the sources whence a beautiful ornamental stone can be procured it ought not to be forgotten.

Both these beds of limestone extend southerly across the river into Becket, and one of them, probably the most easterly one, appears in the southeast part of that town, on what is called the Billy Messenger Farm, now owned by the State of Connecticut. Here formerly the stone was burnt into quicklime, as it has been more recently at the most easterly bed in Middlefield: but the kilns are not now in operation at either place: probably because the lime hence obtained cannot compete with the purer lime from the valleys of Berkshire.

The limestone from the three localities above named, (and I might add a fourth which I recently noticed two miles further south on the old Becket turnpike,) is very much alike in its general character; as may be seen in the table of analyses that has been given. The specimen from the most easterly bed in Middlefield is the most free from magnesia and earthy impurities: But there is great inequality in different parts of the bed as to purity, and much of it is rejected as too impure for burning. The fact is, the stone at these localities has been subjected to powerful heat at some former period, and is thereby injured for economical purposes. At present perhaps, it cannot be profitably burnt for the market. But as it exists in a region likely for a long time to abound in fuel, the time may come when this stone may be in demand.

The beautiful dolomitic limestone, a mile south of the meeting house in Tyringham, (No. 1924) which is extensively converted into quicklime, appears to be situated between strata of gneiss, just like the beds in Middlefield and Becket. The same is true in respect to some of the beds in New Marlborough, which are employed for a similar purpose: as at Hadsell's and Smith's quarries. (No. 1927, 1933.)

In the Table of Analyses a specimen is given (No. 2497) whose locality is Worthington, which was received from Dr. Brown of that place. Being informed that extensive ledges of it existed there, I analyzed the specimen; and found it to be the purest limestone which I had met with in Massachusetts. It will be seen that it contains no earthy matter, and no magnesia; and only an extremely small quantity of iron. I have since learnt that only bowlders are found in Worthington; and the probability is strong, that they were brought from Berkshire county.

I ought here to remark, that though in several instances no iron is given in the analysis, it is only because no attempt was made to separate it from the other ingredients, and I have reason to think it always exists in our limestones.

Blanford Limestone.

A small bed of limestone shows itself in the northwest part of Blanford, one mile south of a bed of serpentine, which, as well as the limestone, occurs near the junction of mica slate and hornblende slate; which last is narrow and succeeded by granitic gneiss. The character and composition of this limestone are very similar to that of Middlefield and Becket; and therefore additional description will be unnecessary.

Micaceous Limestone of Franklin and Hampshire Counties.

In the mica slate region of Franklin and Hampshire counties, especially near its eastern border, a gray highly siliceous limestone occurs, which usually abounds also in mica. Indeed, it passes insensibly into mica slate, and is not generally distinguished from that rock. The table of analyses exhibits the composition of six specimens of this limestone; viz. two from Whately, two from Ashfield, one from Norwich, and one from Southampton, all of which contain a large proportion of earthy impurities; and one of them a little magnesia. I also ascertained the existence of magnesia in a specimen which I analyzed from Williamsburgh; which contained 63 per cent. of carbonate of lime.

This limestone is most abundant in the towns of Whately, Conway, Colrain, Buckland, and Ashfield: and in my former reports I suggested that some of it was pure enough to be burnt, especially for agricultural purposes. A company has since been formed, belonging to Hadley and Northampton, who have for several years burnt more or less of that in Whately, where occurs the largest and probably the purest bed of it that I know of. They have erected a perpetual kiln, and use the lime principally upon their land: and as they inform me, with good success. This is the first systematic and persevering effort, so far as I know, that has been made in Massachusetts to burn limestone for agricultural purposes: and hence deserves warm approbation and encouragement. This same stone, however, has been burnt in Buckland and applied successfully to land. But I believe its preparation is now abandoned. I have been told also, that it was formerly burnt on a small scale in Colrain. Some of it is obviously too impure to be profitably burnt. For in England a stone that does not contain more than 50 per cent. of carbonate of lime, is regarded as too impure for being profitably converted into quicklime. Hence if any are about to engage in burning this micaceous limestone, they should first resort to a chemist to ascertain the amount of lime which it contains. I shall have occasion to speak of the Whately lime in another place, as a valuable article for a particular kind of mortar.

I have conversed with most of the gentlemen concerned in the preparation of lime at Whately, who are all respectable farmers, and they assure me that the experiments which they have made with that lime upon their land, afford in most cases decided evidence of its good effects. Mr. Linus Green says he has tried it in a variety of ways, both upon grass and ploughed ground; and in such a way as to be able to judge of its effects; and in most cases it proves of marked benefit. Sometimes he has sowed it, after it had been slacked for some time, directly upon grass; or upon hills of corn, or potatoes; or has mixed it with loam, or with manure; and he rather prefers the latter mode. Mr. Nash and Son, have made numerous trials within a few years past with this lime, and the latter has been so good as to put down the facts upon paper: and as the experiments detailed seem to me to have been very well conducted, and the results important, I give his letter entire.

SIR,—You wish me to communicate to you any facts respecting the use of lime on my Father's farm which we may have observed.

We have had but little experience on this subject, having commenced using lime in the spring of 1837. The fall previous we had plowed a piece of low, clayey, pasture ground, which had, probably, never been plowed before. As we had intended to make some trial of the effects of lime on this piece, we had, in plowing, divided it into lands, the furrows of which ran east and west. As the land was soft we could not well do any thing with it till the fore part of June. At that time we carted upon the *south land*, ten loads of manure to the acre, of about 30 square feet each.

On the next land we put fifty bushels of lime to the acre; which, at twenty cents a bushel, (about its actual cost,) would amount to the same as the manure. On the north land we put no manure or lime. On the 11th. and 12th. of June, the whole was sowed with oats, seeded, and harrowed in.

In harvesting it was not convenient to keep the oats which grew on these several lands separate, so they were all mixed together,—our object being not so much to get the exact yield of each, as to satify ourselves by inspection and harvesting whether lime had an effect on land of this description. Of this we felt satisfied, for the oats on the land which had been limed were heavier and yielded a third more sheaves, than the land which had been manured,—though the yield there was considerably better than on land on which nothing had been put.

We have mowed these lands in 1838—9, and get as much in quantity and better in quality from the limed land than from both the others.

In the sping of the same year (1837) we planted two pieces of potatoes on land of equal richness or as near as we could judge. One piece was manured in the hole with common barn-yard manure, at the rate of ten loads to the acre. The other was manured from a heap of compost which had been thrown together about ten days before using. Its composition would not, probably vary much from two thirds manure and one third loam with two bushels of lime added to a load. When it was used it was was all in a state of fermentation, though this had not proceeded so far as to destroy any of the manure. The same quantity was applied to the acre as before. This last piece yielded 250 bushels to the acre, while the former did not exceed 150. Perhaps this difference may appear to be great, but the land and potatoes were carefully measured.

In 1838, lime was mixed with all the manure which we intended to use on potatoe land, except a *part* of one piece, which was left further to test its effects. We did not measure the potatoes, but it was the opinion of my father, expressed at the time, that the same quantity of land limed yielded 1-3 more than the unlimed. The potatoe crop of 1838, you will recollect, was almost universally poor, both in quantity and quality. In either respect however, ours did not appear to be much inferior. This was probably owing in part to their being planted on low land, which enabled them better to resist the drought of that season. But the potatoes were evidently *better* on the limed than on the unlimed parts.

In 1839. we made no further experiments, having used lime for all our potatoes.

For the three last years we have used lime on mowing by mixing it with compost, and although we have never made an exact comparison of limed and unlimed parts by measuring the land and weighing the hay, yet the grass has evidently been better where the lime has been applied.

But whatever may have been the effects of lime on oats, grass and potatoes, we cannot see that it has benefited wheat or rye. Indeed we have been disappointed whenever we have applied it to either. In April 1838 we sowed ten bushels on 3-4 of an acre of winter rye. It appeared to kill most of the sorrel of which there was considerable among the rye, but the rye did not appear to be better than on land around it which had received no lime. On the 12th. of April, 1838, we sowed half an acre of wheat on a part of the piece which had the previous year yielded 250 bushels of potatoes to the acre. The 4th. of May, 20 bushels of lime were sowed

upon it, the blade being then about 3 inches high. We got only six bushels of wheat from the half acre, and that badly shrunk.

On the 6th. of Oct. of the same year we sowed one acre of winter wheat on old land, after corn. On this acre we sowed 45 bushels of lime and harrowed it in with the wheat. Part winter killed. The remainder grew remarkably well and promised a good yield, until it got into the milk state, when it commenced rusting. The crop was spoiled. So completely was the kernel robbed of its nourishment and shrivelled up that it was hardly worth thrashing. Only 3 1-2 bushels were thrashed from the whole of it. It may, perhaps, be proper to inform you that this piece after turning under the stuble was sowed with turnips. As they were sowed late we did did not expect much of a crop. We gathered something over 150 bushels of first rate roots remarkably free from worms.

Last spring we sowed one bushel of Italian-spring wheat on 95 rods of land and seeded it down. About a fortnight after 10 or 11 bushels of lime were sowed upon it. There was a large crop of straw, sufficient to have yielded 25 bushels per acre. But it was affected by the rust and we got only eight bushels from the piece, which would be 13 1-2 bushels per acre, nearly. The clover and herdsgrass look remarkably well.

All the lime we have used was burned at Whately. The cost of fuel for burning in the draw kiln has varied from three to four cents a bushel. Wood, half hard and half soft, 4 feet long has usually cost from 9 to 10 shillings per cord. The Company pay 6 1-2 cents a bushel for quarrying and burning.

Very Respectfully yours.
SAMUEL NASH.

PROF. E. HITCHCOCK.
Hadley, Dec. 3, 1839.

Limestone of Whitingham, Vermont.

I mention this bed of limestone, first because it is so extensively used in Massachusetts, and secondly because it very probably extends into Massachusetts. It lies in the south part of Whitingham, near the junction of talcose slate and gneiss, and in external character resembles that in Middlefield and Becket, though perhaps rather more pure. I have not analysed it, but cannot doubt that it contains magnesia.

Limestone of Bernardston.

This limestone is associated with a bed of magnetic iron ore: and some 40 or 50 years ago, an attempt was made to smelt the latter, making use of the former for a flux. But not being very successful, very probably from the presence of some oxide of manganese, the enterprise was abandoned; and it was not till a few years ago that any effort has been made to burn the limestone. As we might presume from the analysis, it produces a very good lime for cement, and doubtless good also for agriculture. A good deal of hydrate of iron is occasionally intermixed with the limestone, which gives the lime a dark color: but this is not probably of any injury when it is employed for mortar. The bed is of considerable extent and obviously of a more recent age than the limestone that has been described: for it contains some organic remains.

Fetid and Ferruginous Limestones of Hampden County.

These occur in the bed of Chicopee River, at the Chicopee Factory Village, in Springfield, and in West Springfield on the banks of Agawam river; and also in the northeastern part

of the town. Two quarries have been opened at the latter locality and the fetid limestone burnt to a considerable extent for hydraulic cement, by Mr. Paine. But the ferruginous limestone, which often exists in the form of septaria, has never been used at all. Nor have any of these limestones that I can learn, ever been employed in agriculture; although I cannot doubt but they would answer admirably well. I shall have occasion to refer to them again when I treat of the application of our limestones for cements. I would only remark here, that though the beds of these limestones which exist in the red sandstone formation, are thin, yet most of them are extensive, and will last for a long time.

Limestone in Belchertown.

About a mile southeast of the village in Belchertown, a bed of limestone occurs in gneiss: which at the surface appears of no great extent: and most of it is impure, though sometimes highly crystalline. It has never however, been explored to any extent: and not unlikely it may hereafter be found of value.

Limestone of Bolton, Boxborough, Acton, Littleton, Carlisle, Chelmsford, Natick and Sherburne.

I notice all these beds of limestone together, because they occur in the same rock, and are very much alike in their characters. They are generally white crystalline limestones, highly magnesian, and almost destitute of stratification; placed between highly inclined strata of gneiss. The rock is usually very much mixed with foreign minerals; such as scapolite, serpentine, compact feldspar, &c. although such portions are mostly rejected. None of the beds are of any great extent in the direction of the strata; nor is their width more than a few yards in any case. Most of them have been opened at different periods, and the stone burnt into quicklime; but nearly all of them are now abandoned; probably because the price of fuel has so increased that lime may be obtained at a cheaper rate from a foreign market. At Bolton, however, a good deal of limestone is still burnt.

In several of these towns, as Chelmsford, Bolton, and Natick, there are several beds of this rock, more or less remote from one another. In the latter place, the rock was formerly dug and burnt during the revolutionary war, from a bed a mile or two northeast of the meeting house; and more recently some of it has been ground for use upon land. No. 1946, shows the composition of this rock. A much purer and highly magnesian specimen, was dug out at the rail road excavation near the same spot, of which No. 1948, in the Table of Analyses, shows the composition. In the same cut a yellow compact limestone was discovered, which forms a bed 4 or 5 feet thick, of which Nos. 1950, 1951, give the composition. The specimen analyzed from Sherburne, was found a short distance southeast of the meeting house; where it occurs in numerous blocks in the stone wall: but I did not discover it in place. And as this spot is nearly south from West Natick, where the limestone above described is found, it is possible that the Sherburne stone may have been brought from that place by diluvial action. More probably, the Natick bed extends to that place beneath the soil, and not improbably a little research might discover it. And really, I regard the discovery in any place in New England, of a good bed of limestone, as of more importance then a mine of gold: for though at present in the eastern part of Massachusetts most of the lime used is brought from Maine, yet the time must come when the price of this foreign supply will be so high, that the inhabitants will be obliged to re-explore the now deserted beds of this rock.

Concord Limestone.

In the southeast part of Concord, on the bank of a branch of Concord river, where it is crossed by the great road leading from Boston to Bolton, I recently found gray limestome in hornblendic gneiss, forming beds from a few inches to several feet in width. It is impossible to determine without excavation, whether enough of good limestone could be found here to make it an object of economical interest. This limestone so much resembles the including rock, that they are apt to be confounded, especially when obscured by disintegration and lichens. It will be seen by the analysis, that this limestone is almost free from magnesia: and that it does not contain so much of siliceous impurity as to make it unprofitable for burning.

Limestone of Stoneham and Newbury.

I put these beds together because they both occur in sienite or perhaps in a rock intermediate between hornblendic gneiss and sienite. The Newbury limestone, of which there are several beds not far from one another, resembles that already described in Bolton, Natick, &c. But that at Stoneham is a beautiful white compact stone, well adapted, were it free from fissures, for statuary marble. It contains, however, more than its appearance would indicate, of silica; and is considerably magnesian. The limestone both of Newbury and Stoneham has been extensively excavated in past time, but is now neglected. Yet let it not hence be inferred that it will never come into use.

Limestone of Walpole and Attleborough.

In both these towns I suppose the limestone to be associated with the rock usually denominated graywacke. That in Attleborough is certainly thus situated: forming a bed, perhaps only a few inches, but probably a few feet wide, in the red slate, in the southwest part of the town, on land of Thomas Arnold. As I noticed blocks in the vicinity quite frequently, I suspect that it may occur there in large quantity: and the analysis shows it to be a very pure limestone. The bed in Walpole lies in the southwest part of the town, and was formerly explored and burnt. It is of a gray color and contains a good deal of siliceous impurity.

The greater part of the quicklime used in the eastern part of Massachusetts, is brought from Thomaston in Maine; and from Smithfield in Rhode Island. The quarries in the latter place are only a short distance from Massachusetts; and the stone being of a good quality, it is extensively wrought. A few years since 20.000 casks of lime, containing from 38 to 40 gallons each, and selling at $2 per cask,—was put up in Smithfield. There are two beds of the rock, about 2 miles apart, in hornblende slate. The color is white and the texture crystalline.

Perhaps I ought to mention, that among the slate of the stone walls in the west part of West Newbury, I noticed blocks of white limestone (No. 1945). Probably they are derived from a bed at no great distance; as they were not rounded; and careful examination might bring it to light.

I doubt not but many of the above localities of limestone will be new to most of our inhabitants, as they were to me a few years since. I have felt it to be important to describe them all, in the belief, that though now in a great measure neglected, they will ultimately be regarded as of no small value.

The three last specimens, whose analysis is given in the Table, are those singular concretions

called claystones, which are common in our clays; and which appear to contain about 50 per cent. of carbonate of lime. They occur in too small quantity to be of much economical value; and I shall, therefore, reserve a description of them to the more exclusively scientific part of my report.

II. SUBSTANCES CONTAINING LITTLE OR NO CALCAREOUS MATTER, BUT OPERATING UPON SOILS VERY MUCH LIKE LIME.

1. *Green Sand.*

This substance constitutes a large part of what in New Jersey goes by the name of marl; and which, within a few years past, has wrought such wonders in some parts of that State. It is found also in Virginia, and probably exists in all the Southern States, that extend to the Atlantic. In my report of 1834, I described this substance as forming a bed of considerable thickness at Gay Head, being a part of the tertiary formation there. I also intimated in the same place, that probably it existed on the continent at Duxbury. This point I determined if possible to settle, and proceeded to Duxbury accordingly. And in the extreme north-westerly part of the town, or rather for the most part within the bounds of Marshfield, about two miles southwest from the seat of Hon. Daniel Webster, I found the spot described by Rev. Mr. Kent, as given in my report. I was surprised to find the region abound in low hills of granite, with occasionally a swamp or small stream; being in fact, as unpromising a spot for green sand as I had seen in the State. Yet here I found that the green sand had been thrown up from at least three wells; one of which (on widow Sprague's place,) is in Duxbury, and the other two in Marshfield, near a small stream called South River. In the well on Mr. Kent's farm, (that described in my report as in Duxbury,) the green sand was struck at the depth of 13 feet from the surface. In the other, that on the farm of John Chandler, Jr., it was struck at the depth of 21 feet; and the bed was five feet thick. This spot was nearly 20 feet above South River; and it occurred to me that perhaps on the margin of the stream the sand might be found, just beneath the surface. I caused an excavation to be made there, and after passing through one foot and a half of black mud, and the same distance through yellow sand and gravel very much consolidated, I had the pleasure of reaching the green sand. This spot is perhaps 15 or 20 feet above tide water. An extensive swamp extends from this place through the west part of Duxbury several miles, and I have reason to suppose the green sand may be found along its whole extent. Indeed, I strongly suspect that it occurs abundantly along the coast from Marshfield to Plymouth, and not improbably also on Cape Cod. The general aspect of a large part of Plymouth and Barnstable counties is very much like the region where this substance occurs.

The coloring matter of this sand forms but a small proportion of the whole mass wherever it has yet been found; yet it imparts a decided green tinge to the whole. The specimens which I obtained at Marshfield, however, contained probably much less than the average quantity of the green matter. For some of it had been exposed to the action of rain, &c, for several years; having been formerly thrown out of a well; and that from the excavation which I made, was obtained only a few inches below the upper part of the bed. The specimen in the State collection, (No. 158,) bears a stronger resemblance to the green sand found on the continent of Europe, than to that from New Jersey. It became a point of much importance to identify this with other green sands. This could be done only by chemistry: and I am happy to be able to present here the very accurate results of analysis, which Dr. S. L. Dana, at my request has obtained, whereby the identity of this green sand with that of Europe, is completely established.

"The *green sand* from Marshfield," says he, "was treated as follows to separate the green particles. Washed in a large volume of water, the black brown, and green particles subside, mixed with many quartzy grains. The grains form about one half the whole bulk. These grains were then washed in a smaller quantity of water, and the attrition caused the water at each successive washing, to become ochrey, and I began to think that I should wash nearly all away.* I then treated the grains with dilute muriatic acid—washed them anew, dried and passed them through a sieve. The whole looked like mustard seed, with a few light green particles here and there among the black, green, and brown particles and quartzy grains. Pulverized, the whole becomes ochre brown. It was dried at 212°, and the analysis conducted as usual, gave—

Water,	6.50
Black Oxide Iron, (ferroso-ferrique of Berzelius,)	64.944
Alumina,	4.372
Silex,	23.0
Lime,	0.536
Magnesia,	0.648
	100.

"The earths, if silicates, will require 4.721 silex; and on no supposition will the remaining silex and water convert the iron into a hydrated silicate. Hence the iron is not combined with the silex, but exists as a hydrated oxide of iron. The composition will then be; free silex, 18.289; hydrated oxides of iron, 71.444; silicates

$$\text{of}\ \frac{\text{alumina, } 4.372}{\text{silex, } \quad 3.886} + \text{of}\ \frac{\text{lime, } .535}{\text{silex, } .316} + \frac{\text{magnesia, } .648}{\text{silex, } \quad .519} = 10.277.$$

* The specimen which I sent Dr. Dana, had probably lain upon the surface of the ground for several years, and the iron had most likely become somewhat peroxidized."

If we allow the hydrated iron to be mixed, a portion with the above silicates, except the lime, which Berthier and Turner did not find essential in their analyses of the coloring matter of green sand, we have a small portion of this coloring matter mixed with a large portion of hydrated oxide of iron. Only about 5 per cent. of the whole is green sand, similar in its composition to that examined by the late Professor Turner, as stated in Dr. Fitton's "Remarks on the Strata below the chalk, &c., in the south east of England;" p. 108.

In a subsequent letter, Dr. Dana gives the result of his analysis of the green sand from Gay Head, of which No. 72 in the State collection, in the rooms of the Boston Natural History Society, is an example. This gives a better idea of the ordinary appearance of this substance than the specimen from Marshfield.

"I have finished the Vineyard green sand. It is very near the results of Turner. I washed the whole in water, poured off the light part, washed the remainder repeatedly, reserving the washing, which let fall a fine powder of a decided green tinge, feeling, when dry, under the pestle, like soapstone powder. The residuary quartzy grains were rejected, a few fine green particles among them. The second portion alone, was taken as the best sample of coloring matter, and gave—

Water,	7.000
Silica,	56.700
Alumina,	13.320
Oxide of Iron,	20.100
Lime,	1.624
Magnesia,	1.176
Manganese, traces, and loss.	0.080
	100.

"The water and iron are nearly the same, the alumina the mean, and the silica about 6 per cent. more, than the analysis of Turner and Berthier. No doubt therefore it is a true green sand."

The above analyses do not give the actual per cent. of this green substance in the soil where it is found, though it evidently cannot form a large proportion. But this is not necessary in order that very decidedly good effects should result from its use in Agriculture. The following extract from the report of Professor Henry D. Rogers, on the Geology of New Jersey, bears on this point as well as upon the general value of green sand in the cultivation of the soil.

"When we behold," says he, "a luxuriant harvest gathered from fields where the soil originally was nothing but sand, and find it all due to the use of a mineral sparsely disseminated in the sandy beach of the ocean, we must look with exulting admiration upon the benefits upon vegetation, conferred by a few scattered granules of this unique and peculiar substance. The small amount of green sand dispersed through the common sand, is able, as we behold, to effect immeas-

urable benefits in spite of a great predominance of the other material which we are taught to regard as by itself so generally prejudicial to fertility. This ought to exhibit an encouraging picture to those districts not directly within the limits of the marl tract, where some of the strata possess the green substance in sensible proportion. It expands most materially the limits of the territory where marling may be introduced and points to many beds as fertilizing, which otherwise would be deemed wholly inefficacious."

In another place of his most valuable Report, Prof. Rogers says, that "Mr. Woolley manured a piece of land in the proportion of two hundred loads of good stable manure to the acre, applying upon an adjacent tract of the same soil his marl in the ratio of about twenty loads per acre. The crops, which were timothy and clover, were much the heaviest upon the section which had received the marl, and there was this additional fact greatly in favor of the fossil manure over the putrescent one, that the soil enriched by it was also entirely *free of weeds*, while the stable manure had rendered its own crop very foul." Placing the home value of the farm yard manure at one hundred cents for each two horse load, and that of the marl at twenty-five cents per load, we have the expense of manuring one acre 200 dollars, of marling the same 5 dollars." "Land which had been sold at 2 1-2 dollars per acre, in consequence of the permanent increase in its fertility from the marl, is now worth 37 dollars the acre."

There is one fact, however, that will throw a doubt over the probable utility of this substance in Massachusetts. By taking the average of eight very accurate analyses of the New Jersey green sand, as given by Prof. Rogers, we find that it contains 10 per cent. of potassa. Mr. Seybert's analysis gave nearly the same amount, and Mr. A. A. Hayes informs me that in two varieties analyzed by himself, he found 7 per cent. of dry oxide of potassium. But only a trace of potassa was found by Dr. Dana in the Massachusetts green sand, which, in this respect, compares with the English green sand analyzed by Prof. Turner. Now Prof. H. D. Rogers imputes the value of this substance in agriculture almost exclusively to the potassa which it contains; and no chemist will doubt but that this ingredient will exert a very salutary influence upon soil. Yet there are other ingredients in the green sand, which some will suppose may increase its fertilizing power. One of these is the protoxide of iron, whose quantity is large, and which Prof. William B. Rogers, of Virginia, supposes may be of service, by its alkaline character, upon vegetation. This view will receive confirmation by some facts and reasonings that will be presented when I come shortly to speak of the application of clay in agriculture. It is probable, also, that the lime and magnesia in the Massachusetts green sand, may aid in a similar way. That all the good effects of this substance upon soil in New Jersey cannot be imputed to the potassa, seems probable, from the fact that granite and gneiss contain quite as large a proportion of potassa, and when spread in a powdered or decomposing state upon the soil, ought, therefore, to fertilize as much as the green sand; especially as Mr. Hayes informs me that the New Jersey green sand "decomposes in nitric acid slowly, being less soluble than some feldspar." But there is no evidence that the good effects of the granite and gneiss are as great as those of the green sand; and hence we must call in the aid of some other ingredient to explain its fertilizing power.

I do not, therefore, despair of our green sand in agriculture. It certainly deserves a fair trial, when we consider what a change this substance is producing in much of the poorest land in New Jersey and Virginia. It would be very easy to obtain an abundance of it at Gay Head, where it occurs in great quantities, towards the north end of the cliff. Or I doubt not but it may be found in many places along the coast in Barnstable and Plymouth counties, a few feet beneath the surface, in the lowest places. Very likely a little research may bring to light varieties that contain potassa; and should this be the case, the change that might thereby be produced in the agriculture of the south-east part of Massachusetts, can hardly be calculated.

After Dr. Dana had favored me with the analysis of the Green Sand of Massachusetts above given, it occurred to me, that as I took the specimens from near the surface, it was possible they might have lost their potassa by the action of atmospheric agents, and I accordingly visited Gay Head again, and obtained specimens at some depth from the surface. These I subjected to analysis, by the method recommended by Prof. Henry D. Rogers, in his Report on the Geology of New Jersey, p. 93. A portion of this sand (No. 208) was washed three or four times, and the lighter part poured off. The residue consisted of grains of quartz and green sand: 30 grains of which yielded as follows:

Water,	2.70
Silica,	19.80
Protoxide of Iron,	5.80
Alumina,	1.20
Lime,	0.17
Loss,	0.33
	30.00

30 Grains of the washings, treated in the same manner, yielded. as follows:

Water,	4.10
Silica,	18.90
Alumina,	2 20
Protoxide of Iron,	4.25
Lime,	0.11
Loss,	0.44
	30.00

I could not discover a trace of potassa or magnesia. By visiting Gay Head, I ascertained that the stratum of green sand there has a northeasterly dip of about 40°; and that measured horizontally on the beach, its thickness is about 50 feet; so that the quantity is very great should it ever prove of any service.

2. *Clay.*

There is abundant evidence that our common clays are of great value when spread upon land. I find that they have been used to a considerable extent in the state; so commonly, indeed, that I abandoned the idea I had formed of giving a detailed account of particular instances. So far as my inquiries have extended, the testimony is decided that our blue clays exert a very favorable effect upon the soil. When spread upon sandy ground we might expect that they would render it a better reservoir for salts and geine. But thoroughly to ameliorate our sandy soils in this way, requires far more clay

than is usually employed, and I am perfectly convinced that they exert other than a mechanical influence; that in fact, their effect is analogous to that of lime. I refer here to the blue clays which are far the most common. As to the white clay I have not learnt its effect upon the soil; but from the fertility of some of the soils in Kingston, Plymouth, and Barnstable, where white clay is mixed naturally with sand, I presume this sort is equally valuable with the blue.

In view of the wide extent of our beds of clay, and the use that might be made of it upon land, I felt desirous to ascertain to what principle it owes its fertilizing powers; and therefore subjected a few specimens to analysis in the ordinary way by fusion with alkali. The following are the results. I omit however certain white clays, which I found destitute of iron, and therefore probably not very likely to be of much value upon land. But for other purposes, of which I shall speak shortly, they are of a good deal of importance.

Analysis in the Dry way by Alkali.

No.	LOCALITY.	Water and Organic Matter.	Silica.	Alumina.	Prot-oxide of Iron.	Oxide of Manganese.	Lime	Magnesia.	Sulphur and Loss.
139	Northfield; blue.	10.8	46.93	28.97	9.9			0.1	2.9
140	Sunderland; light blue.	8.2	49.00	29.15	13.1	0.15	slight precip.	0.4	
142	Kingston; white.	3.5	71.00	16.30	7.3	0.30	do	0.3	1.3
143	Lowell; white.	4.0	61.52	20.50	9.2	0.56	0.56	0.44	3.29

I tried some of our blue clays also, for geine; but in general they yielded only very little, and perhaps none. For so strongly do they retain water, that not improbably all the loss, especially of soluble geine, might have been imputed to this substance, which had not been all expelled by a heat of 300° F.; and then the peroxidation of the iron by ignition, renders this method of analysis quite uncertain. I, therefore, omit the results; only observing, that the amount of sulphate and phosphate of lime obtained, was about the same as in good soils. I therefore suspect that we must impute most of the good effects of clay as a manure to the large quantity of iron which it contains. On this point, however, I will present some suggestions of Dr. Dana, witn which he has kindly favored me.

"If we attempt," says he, "to account for the action of *clay*, independent of its amending a sandy soil, we should bear in mind that all our common clays contain more or less of sulphuret of iron. The conversion of this into

the persulphate of iron is the natural consequence of exposure: free sulphuric acid then results, which acts on any lime in the soil, forming sulphate of lime: (the Gay Head crystals of sulphate of lime are so formed:) so that by spreading clay, we spread plaster. The iron in clay also plays its part thus. It is evident from Chaptal's experiments, that protoxide of iron is not beneficial in agriculture. He attributes this to the oxidation of the iron, depriving the plant of its intended oxygen. Nature is no niggard; nor is the reason of Chaptal very philosophical. We have seen above that protoxide of iron does not act on geine. Now by exposure, the protoxide becomes peroxide; and then, I conceive begins an action similar to that of lime. If the free sulphuric acid, produced as we have supposed, finds not lime enough, it will decompose all earthy geates, and thus a fresh portion of nutriment is set at liberty. Both the effects of clay—the production of plaster and the formation of peroxide of iron, are speedily produced by burning the clay, as is often practised."*

Still more recently, Dr. Dana adds the following: "Some facts have lately come under my eye, and have recalled others to mind, which I have followed up experimentally; all tending to show, *that if iron peroxidates itself in contact with vegetable fibre, the texture of the vegetable fibre is weakened,* and geine is produced, and that *in a few hours. It is during the passage from protoxide to peroxide, that the 'saponifying' action takes place,* geine is produced, and then *combines with peroxide.*"

In the few analyses which I have given above of our clays, I have considered all the iron in them as existing in the state of protoxide; although I made no attempt to ascertain whether some of it might not be a peroxide. Very probably this may to some extent be the case: especially where the clay has a yellowish tinge. Yet for the most part, I doubt not it is a protoxide. A slight error here cannot affect the reasoning above presented.

I hope our farmers will make more numerous and accurate experiments upon the use of clay as a manure; not merely upon sandy land, but following the suggestion of Dr. Dana, upon other soils, in the expectation that its action will be analogous to that of lime. Probably, the best clay for this

* The agency of geine in the fermentation of manure is thus explained by Dr. Dana with his usual clearness and felicity.

"By fermenting dung vast volumes of ammonia are liberated. I do not think that it is the action of gases as such, which we want, or which nature intends as food of plants to be derived from the soil. The air is always full of all which the fermenting manure can supply in a gaseous form. The true actions of ammonia and carbonic acid resolve into their effects on geine. The ammonia combines as alkali with that, and thus it becomes very soluble, and the carbonic acid produces sur-salts of the earthy geates of lime and magnesia. It is these, liberated the moment the plant demands them, which cause all the geine of the manure to become alcaline soluble geates."

"How wide is the influence of geine! It not only enters by itself into the food of vegetables but becomes the very solvent which nature has prepared to act on the alkalies, earths and oxides, dissolving them as they are liberated from decomposing granitic sand."

purpose occurs in the valley of Connecticut river; but it abounds in almost every part of the state, and perhaps it may in a good measure supply the deficiency of lime. It will of course require to be laid on in much greater quantity than marl, and probably, as in the case of marl, too much may be used. How much ought to be used is a fair subject for experiment.

3. *Decomposing Rocks that contain Feldspar.*

Feldspar and mica contain quite a large proportion of potassa; a substance well known to be valuable in agriculture. And these minerals constitute a large proportion of several of our most common rocks; such as granite, sienite, greenstone, porphyry, gneiss, mica slate, and graywacke. Hence we might predict that these rocks, recently decomposed or reduced to fine powder, would form a good dressing for land; especially when we reccollect that the same rocks contain a fair proportion of iron. Now some varieties of them are very liable to decomposition: and when partially crumbled down, if ground in a plaster mill, they will be brought into a proper state for such a use. These suggestions, however, are more the result of theory than of actual experiment: although such a use of powdered rock has sometimes been made and found of value. Indeed, an example of the good effects of decomposing gneiss upon cultivation was pointed out to me in the south part of Athol: and No. 100 presents a specimen of this substance, obtained nearly a foot from the surface in a ploughed field, but not below the point to which geine had penetrated; as appears from the analysis. Yet as this is insoluble it could not affect the vegetation but slightly. The salts of lime also are not in large proportion, and very probably its good effects, which were not represented as great, may have chiefly resulted from the liberation of potassa from the mica and feldspar.

Now there is a great deal of partially decomposed rock in the formations of this State, which have been named above, and they constitute at present the most barren spots in our soils: because they are not reduced fine enough to form a good soil; or because they are too strongly impregnated with stimulating salts. Perhaps if spread over soils already containing geine, they might operate favorably upon crops. At least, it seems to me there is so much plausibility in the theoretical suggestions above made that it would be desirable to make this experiment on a small scale, since it is so easy, even if it be necessary to reduce the crumbling rock to powder in a mill. In England decomposing trap rock is mixed with lime, and forms a valuable dressing for land. *De la Beche's Report on the Geology of Cornwall and Devon. p.* 471. Those who have farms on the trap ranges of the valley of Connecticut river, would do well to try this experiment.

4. *Hydrate of Silica.*

In describing our marls I have already referred to this substance, which is quite common beneath our peat bogs. In its purest state, as it exists in No. 157 from Spencer, it exceedingly resembles carbonate of Magnesia, in color, levity, and taste; although easily distinguished by chemical tests. When mixed with some vegetable matter, as in Nos. 162, 170, and 171, from Barre, Andover, and West Bridgewater, its color is darker This is its most usual mode of occurrence: and I doubt not but it exists in considerable quantity in every town in the state. In addition to the localities named above, I have specimens from Manchester, Sturbridge, Fitchburg, Wrentham, and Pelham. Usually it is found in layers only a few inches thick: but sometimes its quantity is much greater. Mr. Alonzo Gray of Andover, describes one bed in that place, as 17 feet in thickness, beneath a layer of peat from 2 to 6 feet, extending over an area of sixa acres. For one or two feet immediately beneath the peat at this spot, this peculiar substance is mixed with vegetable matter, and this is considered worth half as much as manure for land. It has been used somewhat extensively in this and other New England States as a fertilizer, and with decided benefit. With a view to ascertain what principle gives it value upon land, I subjected two specimens to analysis. The first was the pure white variety from Spencer, No. 157, which afforded the following results in 100 parts, by fusion with 2 parts of carbonate of Soda and 3 parts of carbonate of potassa.

Water,	12.00
Silica,	81.14
Alumina,	5.61
Peroxide of Iron,	0.59
Lime,	0.12
Magnesia,	0.24
Manganese and loss,	0.30
	100.00

A specimen from Barre (No. 169) gave the following results.

Water,	12.00
Organic Matter,	3.0
Silica,	66.42
Alumina,	9.40
Peroxide of Iron,	6.11
Lime,	1.01
Magnesia,	1.41
Loss,	0.65
	100.00

From these analyses we perceive that this substance is essentially composed of silica and water; and is hence, in scientific language a hydrate of silica. The specimen from Spencer did not change its color when ignited, and therefore contains no organic matter, either vegetable or animal: but that from Barre became black when strongly heated; showing the presence of such matter. Assuming the water to be the same as in the Spencer specimen, I hence determine the amount of organic matter to be 3 per cent.

From these analyses we can discover only two circumstances that can give this substance value as a manure: the first is, the presence of organic matter, probably in a very favorable state for promoting the growth of vegetables; the second is its remarkable hygrometric properties, which might make it especially valuable upon dry soil, or in time of drought. The latter of these properties only, can give any value to the Spencer specimen. But since the publication of my report of 1838, I have ascertained the astonishing fact, that the siliceous part of this substance is made up entirely of the shields or skeletons of animalculæ, that once lived and died in the waters from which it was deposited!* And perhaps in this fact we may see another cause for the fertilizing power possessed by it. It may be that some of the soft animal matter, that once covered these skeletons, still remains for the nourishment of plants. At any rate, it must henceforth possess a high degree of scientific interest. But this is not the place to discuss the subject in that light.

If it be desirable to give this substance a less technical name, than the chemical one prefixed to this article, it will be very proper to denominate it *Siliceous Marl.*

III. NATURAL SOURCES OF GEINE, OR VEGETABLE NUTRIMENT, IN MASSACHUSETTS.

Having now pointed out the situation and value, so far as known, of all the calcareous deposites in the State that can be applied to agriculture, and of other substances whose action on soils is somewhat analogous to that of lime, the next grand inquiry is, whether there are any sources in the earth from which additional quantities of geine can be obtained, or matters convertible into geine. I pass by the whole list of common manures, presuming that they will be fully discussed by the Agricultural Surveyor. And I

* We are indebted to Prof. Bailey of West Point for having first ascertained that the Hydrate of Silica in this country beneath our peat bogs, is constituted of the remains of animalculæ: a discovery of very great interest to Geology. *See American Journal of Science, Vol.* 1. *p.* 118.

shall merely notice the natural sources of vegetable nutriment within our limits.

1. *Peat and Mud Swamps.*

The peat and muck mud swamps of New England have become a vast repository of organic matter, which is, and has been, for ages increasing. In addition to the larger vegetables, which, as they die, fall and are enveloped in the soft matter on which they grew, there is a thick mat of moss, which —especially the sphagnum—continues to flourish at the upper part while the lower part dies and decays. In favorable circumstances as to wet and temperature, this mass of vegetable matter becomes converted into peat. Only a small part, however, of what is accumulated, becomes peat of such a character that it answers well for fuel. Often it is too much mixed with mud to be easily burnt, and sometimes the vegetable fibre is scarcely changed. Yet the whole of it is capable of being converted into vegetable nutriment. And I am convinced, from all that I have seen and heard, that Massachusetts contains enough of this geine and vegetable fibre in her swamps, to render all her fields fertile for centuries. In other words, here is an exhaustless source of geine. Some of it is already in a soluble state; and therefore the black matter from swamps, is rarely spread upon soils without producing some benefit. Yet for the most part the geine is in such a state as to require some chemical change before it will become soluble nutriment, fit to be absorbed by roots. It is an important inquiry then, what is the best mode of accomplishing this change. This has been attempted, first, by mixing the peaty matter with good manure in alternating layers, and suffering them to ferment for a long time, the peat being in much the greatest quantity: Secondly, by mixing it in a similar manner with lime; or with lime and manure: and thirdly, by mixing it with alkali, or some compound containing alkali. The principles respecting geine which have been advanced in this Report, will probably enable us to decide as to the preference to be given to any one of these methods. And here I have it in my power to give the opinion of Dr. Dana, whose remarks I am always happy to substitute for my own, on a subject with which he is so familiar, and which he has done so much to elucidate.

"The fact," says he, "that peat or turf is very soluble in alkali, seems not to be known among our farmers. The usual practice of mixing lime with peat or turf is decidedly the worst which can be followed. The geine which constitutes a large part of peat bogs, forms with lime a compound little soluble in water, requiring at least 2000 parts of water to one of geate of lime: and if the compound has been dryed and sun-baked, a still larger por-

tion of water is required: it becomes, in truth, almost insoluble. With alumina, geine forms a compound still more insoluble than with lime; and though the vegetable matter in combination with these earthy bases, is actually absorbed by the roots of growing plants, still the geine is in a state much less favorable than when in combination with alkali. Mix ley of wood ashes with peat, and we form a dark brown vegetable solution: the alkaline properties are completely neutralized by the geine, and very often ammonia escapes from turf when treated by caustic alkali. When we add, that this geine absorbs and retains nearly its own weight of water without seeming moist, it is evident, that with the use of ley or wood ashes, the value of peat as a manure will be much increased."

Dr. Andrew Nichols of Danvers, having had his attention called to the subject by Dr. Dana's remarks in my Report of 1838, performed some interesting experiments with peat mud and alkali in 1839, according to the preceeding suggestions of Dr. Dana. He made use of ashes and potassa; mixing them with the mud, and applying the compound, both in a dry and a liquid state, upon Indian corn, barley, and onions. So striking was the effect, most so upon the onions, that the committee of the Agricultural Society of Essex County awarded to Dr. Nichols a premium of 20 dollars. For the details of this case see the *Transactions of the Essex County Agricultural Society for* 1839, *p.* 35.

In the northeast part of Amherst, Mr. King has a farm underlaid by coarse granite, which has proved as productive as any in the region: and I find that he makes little use of manure: but employs the muck mud from a peat swamp. And he usually spreads it over his land directly from the swamp. But he finds that he must use that which lies two or three feet below the surface, and which has a reddish tinge; and this is fully equal to the same amount of manure: He says that this, when exposed for some time to the air, becomes covered with an efflorescence some sort of salt. Probably this fact may explain in part why mud is best, which is dug from the depth of a few feet.

From these facts may not the farmer derive some valuable hints? May he not find that generally, the lower portion of the muck in his swamp, is in a fit state to be spread at once upon his land; without the trouble of forming with it a compost?

The two principal ingredients of peat are soluble and insoluble geine. It often contains also undecomposed vegetable fibre, more or less of earthy matter, and various salts; such as sulphate and phosphate of lime, sulphate of iron, and sometimes free acid, empyreumatic oil, and different gases. Klaproth has given the following analysis of peat from Mansfeld in Germany.

Carbon,	20.0
Siliceous Sand,	12.5
Alumina,	6.5
Lime,	4.0
Sulphate of Lime,	2.5
Peroxide of iron,	1 0
Water charged with pyroligneous acid,	12.0
Empyreumatic oil,	30.0
Carbonic Acid,	5.0
Oxide of Carbon,	12.5

See Dumas' Chemie Applique aux Arts. Tome Premier p. 592. "We might be tempted to believe," says Dumas, "from the above analysis, that peat differs little from wood: But the essays of Klaproth do not leave any doubt but that nearly all the combustible parts of peat are genuine ulmine; (geine) a result confirmed by the recent experiments of Braconnot on the peat of France."

Three specimens of the peat of Massachusetts, analyzed by the rules of Dr. Dana for soils, yielded the following results.

No.	LOCALITY.	Soluble Geine.	Insoluble Geine.	Sulphate of Lime.	Phosphate of Lime.	Silicates.
1555	Sunderland,	26.00	59.60	4.48	0.72	9.20
6	Hadley,	34.00	60.00	1.36	0.24	4.40
1556	Westborough.	48.80	43.60	1.88	0.12	5.60

It ought perhaps to be mentioned, that I found it impossible to heat these specimens as high as 300° before proceeding to their analysis, because they would take fire below that temperature. I therefore heated them only to 200.°

As the black mud found in numerous swamps, which can hardly be called peat, differs from peat in its composition chiefly by the greater and uncertain amount of earthy matter which it contains, I did not consider it important to subject it to analysis. Enough has been given to show that the chief desideratum in Massachusetts, is not in the amount of vegetable nutriment which her swamps contain, but how best to bring it into a state proper to be taken up by the organs of plants. Undoubtedly Dr. Dana has pointed out the best method by the use of alkali: But when ashes cannot be procured, probably quicklime, mixed with barn yard manure and peat, or muck mud, may be a tolerable substitute: especially where any free acid exists in the peat that needs to be neutralized. In any case exposure to the alternations of heat and cold, dryness and moisture, is very important: except perhaps where the mud contains valuable soluble salts which would thus be washed away.

A substance very hostile to vegetation is sometimes found in our peat and mud swamps, viz. sulphate of iron, or copperas. I have met with it, however, in only one place in Massachusetts; and that was in Hubbardston on land of Willard Earl. The specimen sent me, however, contained only about 0.1 per cent. of sulphate of iron; yet it was sufficient to prevent the growth of any vegetable on the spot. But as this salt is soluble in water, most of it might have been extracted by rain from the specimen which I analyzed.

The antidote for sulphate of iron is lime. This not only destroys the copperas, but converts it into sulphate of lime, or gypsum, which is well known as one of the best fertilizers of a soil. But it is not probable that much of the soil of Massachusetts contains the sulphate of iron. It will be most likely to occur in the low lands, on a belt of country a few miles wide, extending north and south across Worcester County, on each side of the meridian of Hubbardston. On that belt the rocks and the soil often exhibit the color of iron rust, and this results from the decomposition of sulphuret of iron, whereby more or less of the sulphate of iron is produced. But as this is soluble in water, it will soon be either drained off or carried to the lowest spots.

2. *Geic Compound. (Apothemite.)*

On the farm of Col. Moulton, in the south-west part of Newbury, seven miles from Newburyport, occurs a peculiar substance, which, at first view, is pronounced to be a sort of peat; but on applying heat, it is found to be something quite different. Its color is a deep brown, hardly to be distinguished, when in mass, from black. When wet, it is soft and unctuous, and exhibits some degree of elasticity; when sun dried, it becomes quite hard, and receives a polish from hard substances Before the blow-pipe, the coloring matter disappears and a white enamel is formed. From an accurate and very satisfactory analysis which Dr. Dana has made of this substance, it appears, so far as I know, to be a new and undescribed compound. His analysis is as follows:

Water,	13.503
Geine,	19.625
Silica,	36.908
Alumina,	19.197
Peroxide of Iron,	8.826
Sulphate of Lime,	1.542
Magnesia,	.402
Specific Gravity, 2.08	100.

"The earths and oxides," he remarks, "are such as we might expect from the decomposition of trap or greenstone: the geine, I presume, has been gradually deposited from the solution of vegetable matter in water. It has precipitated chiefly in combination with peroxide of iron, forming *pergeate of iron.* The sulphate of lime is doubtless derived from vegetable decomposition. It enters largely into the composition of the grasses; and all our waters, whether of ponds, rivers, or springs, contain, so far as I have examined, traces of sulphate of lime. The black coloring matter, or geine, is readily soluble in carbonated or caustic alkali: and keeping this fact in view, I think that, mixed with wood ashes, the above substanee will form a very valuable manure, particularly where the soil is light and sandy."

This geic compound at the locality above named, forms a layer from six to eight inches thick, and sometimes more, over several acres of a deep, basin-shaped cavity, which is nevertheless

dry enough to plough. It did not seem to exert any fertilizing effect upon the soil in that place, but rather the reverse, though on this point I made no inquiries. But probably the geine is too strongly bound to the iron and alumina to be given up without the action of an alkali. Dr. Anthony Jones of Newburyport informs me, that he knows of two other places where this substance is found; one of which is on the north side of Merrimack river in Amesbury. Indeed there is every reason to believe, that it will be found in many places in Essex county, where sienite prevails, and it may therefore, become an object of no small interest in agriculture.

The astonishing power of this substance to absorb water, may be learnt from the fact, that while 100 grains of no soil absorbed, in 24 hours, quite seven grains, 100 grains of this compound absorbed 19.1 grains. This fact shows us that the absorbing power of soils depends much more upon the quantity of geine which they contain, than upon any other ingredient.

Use of this Substance as a Paint.

This geic compound, with no other preparation than that of drying, has been employed as a paint, mixed with oil. It is said to answer a good purpose; and at Col. Moulton's I saw some wood-work covered with it, which appeared well. The color is so deep a brown that it passes very well for black.

It answers, also, as a water color, on paper. By simply grinding it in water and using it for a landscape, the color could hardly be distinguished from that called sepia. Through the kindness of John Tappan, Esq., of Boston, I obtained the following opinion respecting this substance, of a distinguished manufacturer of water colors in New York, to whom it was sent in a crude state, with no information respecting its nature or origin. By simply suspending it in water, it will be easy to obtain a much more delicate variety for the purpose of painting: and as it will probably be found of different shades of color at different localities, it may perhaps be an object to perform some experiments of this sort; for it may prove that it will be more valuable as a paint, than in Agriculture.

"The sample of color," says the manufacturer, "which appears to be a variety of lignite, might probably be of some use, as a deep brown color, for common purposes; but does not appear to have any extraordinary richness or body. It is not sufficiently *brown*, for either sepia or cologne earth, (or vandyke brown), and it is too brown to be sold for black. But if it could be sold quite low, it might come into use for a brown black, or deep brown."

For this geic compound, which appears to be well characterised, Dr. Dana has suggested the appropriate name, *Apothemite:* apotheme being the term applied by Berzelius to a deposits of geine, &c. in vegetable solutions.

IV. SUBSTANCES YIELDING BOTH GEINE AND SALTS.

1. *Marsh Mud.*

I shall delay for a short time upon two other substances, abundant in the state, which may be of no small use in improving our soils, by affording both geine and salts.

Every intelligent farmer probably knows, that Marsh Mud forms an excellent manure; although I apprehend it is employed far less than its value demands. An intelligent farmer in Maryland states, that he "deems it more

valuable than barn-yard manure;" and that "it never failed in any application he had made of it." He also prefers it to marl, because "it is more accessible, its effects are quicker and much more can be done in the way of improvement for the same money." At the same time he confesses, that the permanent advantages of marl are much greater; and thinks that marl and marsh mud will both be improved by combination."* This last remark appears still more important, when we ascertain what it is that gives an agricultural value to this substance. The fact is, it sometimes contains a large quantity of geine, and sometimes but little, while the quantity of the salts of lime, soda, and magnesia, is rather large; so that sometimes a mixture of marl will be of service, and sometimes not. The following analysis of a few specimens of marsh mud, both in the ordinary way and by Dr. Dana's method, will show us, I think, what it is that constitutes its fertilizing power, and afford some useful hints as to its application.

Analysis in the dry way by Alkali.

No.	LOCALITY.	Water of Absorption.	Organic Matter.	Silica.	Alumina.	Oxide of Iron.	Lime.	Magnesia.	Salts soluble in Water.	Sulphuretted Hydrogen and Loss.
135	Newburyport,	3.2	3.3	68.1	14.7	7.4	2.0	0.8	0.2	0.3
136	Medford,	9.5	12.5	50.95	14.9	8.15	1.1	0.2	0.6	2.1

Analysis by Dr. Dana's Method.

No.	LOCALITY.	Soluble Geine.	Insoluble Geine.	Sulphate of Lime.	Phosphate of Lime.	Silicates.	Specific Gravity.
134	Cambridge,	13.0	7.4	2.3	0.4	76.9	1.92
135	Newburyport,	1.5	0.1	3.0	0.5	95.1	2.52
136	Medford.	7.5	5.6	2.6	0.3	84.0	1.92

A substance so rich in geine, or salts of lime and soda, or in both, as the above analyses show, cannot but prove a fertilizer of the soil if spread upon it. If a soil be quite poor, those varieties of mud should probably be chosen that contain the most geine; and this can be judged of by their comparative lightness when dry; the lightest abounding most in organic matter. But if the soil already contain a good deal of inactive vegetable matter, the varieties that abound most in salts will probably be most efficacious; though an additional quantity of geine can do no harm, and may do much good. If marsh mud be applied at random, it is not strange that varieties of it, almost destitute of geine, should be sometimes put upon exhausted soil, and that no good effects should follow. Hence the necessity of some fixed principles to guide the farmer. And since Massachusetts contains so much sea board, and so much land near the coast that may be benefited by this substance, a correct mode of applying it is of great importance.

* Farmer's Register, July 1834; p. 93.

2, *Muck Sand.*

As this substance has never been proposed for use in agriculture, it will be necessary to state the circumstances that have led me to bring it forward in this place.

Ten or twelve years ago, Luther Root Esq., had occasion to dig a well in his garden in Sunderland, where he then resided. This was only eighty rods from Connecticut river, and the land there is alluvial to the depth of more than twenty feet. Near the bottom the excavation passed through a thick stratum of what is usually called quicksand, and which on being thrown out emitted a strong odor of sulphuretted hydrogen. It not being convenient to remove all this earth, it was spread upon a considerable part of the garden, which was a good soil and always well manured. He was warned against doing this, lest it should ruin his garden, and he thinks the quantity spread was not greater than a good coat of manure. The part thus covered was mostly planted with watermelons and other vines: and, instead of injuring the spot, it produced so great an increase of fertility as to astonish himself and his neighbors, and to lead them to search the banks of the river and low places for a similar substance. The good effects continued for two years, and afterwards declined, so that in a year or two the land thus treated was not better than the other parts of the garden.

Seventeen or eighteen years ago, Mr. Rufus Rice had occasion to dig a well on his farm in South Deerfield; and after passing through six feet from the surface, he struck upon what he describes as quicksand, though dry at the time he dug it, and probably mixed with clay. He represents the substance dug out when wet to be almost as much disposed to flow as water, and that it was very difficult so to wall up a well with stones that this sand would not pass through and fill it. He describes it also as giving out a strong odor, and a small quantity which he showed me, that had lain for fifteen years, still retained that odor, and appeared to be identical with the *Muck Sands* to be described in this Report. Wishing to remove the sand thus thrown from a well twenty-two feet deep, and having understood that the effect of a change of soil was good, he carted five loads, after it had lain exposed for a year, upon a piece of plowing, spreading it about as thick as a good coat of manure. This was in the autumn; and the next spring the whole piece was planted with Indian corn, after having been manured in the hill. But that part of the field, which had received the muck sand, soon began to show a much more thrifty growth than the other, and yielded a greater crop. From that time to the present, corn, oats and clover, have been the rotation of crops every three years, except that two crops of rye have been raised upon it, and whenever it was manured, all parts were spread over alike. And even up to the present time, the part on which the muck sand was spread, seventeen years ago, continues to show decidedly more fertility than the other part. I saw this difference in the autumn of 1837, in the crop of Indian corn then growing, and it was considerable.

A few rods from the spot where the well above noticed was dug, another had been excavated three years previously, to the depth of eighty feet, and a large quantity of the muck sand, with perhaps some clay, lay upon the surface; although the well itself had been filled by the caving of the sides. Mr. Rice carried from five to ten loads of this upon a spot of dry mowing, which had almost ceased to produce grass. It was spread about as thick as a good coat of manure, but with no mixture of manure, some time in June. On the first crop of grass that year it produced no effect, and there was not enough grass to be worth gathering. But the second crop was a very heavy one, and consisted mainly of clover which had previously disappeared. The next year the first crop was equally good, the second not so large, though better than middling. In subsequent years the good effects became less and less obvious: but they were visible at least ten years.

The facts communicated to me by Mr. Root (those respecting Mr. Rice's experiments I did

not learn till somewhat later) seemed to furnish a clue that might lead to results of considerable importance.

But the substance that produced such effects upon the soil had all disappeared from the surface, and could not be obtained from the wells. It occurred to me, however, that the same stratum must extend from Sunderland village to Connecticut river; and that its outcrop might be found there, as the banks are more than twenty feet high. A gentleman acquainted with the substance accompanied me thither; and we soon found a stratum of sand several feet thick, which he recognized at once as identical with that dug from the well. Having seen it in one place, I was able to trace it in others. I examined the banks of Connecticut river across the whole state; and wherever they are alluvial, I almost uniformly found this stratum from ten to twenty feet below the general surface. I traced it, also, in many places, in the banks of the Housatonic and Merrimac, the Deerfield and Westfield rivers, and indeed on almost every stream large enough to form much alluvial deposition. On the small streams its depth beneath the surface and its thickness are less. But its leading characters are alike, and somewhat peculiar: and as they made it easy for me to find the stratum, I think I can point them out so that others will be able to recognise it.

The specimens of this substance in the State Collection (Nos. 126, 127, 128, 129, 130, 131, 132, 133,) convey but an imperfect idea of its appearance in its native situation, where it is almost always very wet, and generally exhibits a slightly greenish tinge, though perhaps this results from its mechanical rather than its chemical characters. In the banks of our streams, this stratum is the first one from the surface that arrests the water in its descent into the earth: and hence water is seen oozing out from it in almost every place. It frequently lies immediately above a stratum of gravel. It is also remarkable for its yielding nature when wet: it being easy to run a pole several feet into it, and unless covered with turf, a man in walking over it will sink into it several inches. The cause of its arresting water in its descent, and also of the extreme mobility of its particles among themselves, is probably chiefly dependent upon the fineness of its texture, and the form of its particles, rather than upon its chemical composition. When an attempt is made to dig into it with a spade, or trowel, it conducts very much like soft suet. And yet its composition is decidedly sandy: and therefore I call it *muck sand*, although it generally goes by the name of *quick sand*.

Another important character is, that when fresh dug, this substance almost invariably gives out the odor of sulphuretted hydrogen: that is, an odor considerably resembling that of a gun barrel which has been fired repeatedly with gunpowder. Very frequently, also, there is seen oozing from it a reddish matter of the color of iron rust, and which indeed is the oxide of iron, proceeding probably from the decomposition of the sulphuret of iron, whereby the sulphuretted hydrogen is produced. I am inclined to believe that the odor of the sulphuretted hydrogen is so connected with its fertilizing properties, that I doubt whether any sand, not giving it out, will prove efficacious.

It should also be mentioned, that vegetable matter, even sometimes in the state of fibre, is generally present in the muck sand. Indeed, it seems to be the only stratum, which I have found deep in the earth, that contains much organic matter. In short, it does not differ, so far as I can ascertain, from the rich deposites of mud and vegetable matter, that are now often formed by our streams at high water, except that it has been for a long period in the earth, and thus many important chemical changes have taken place in it, and it has also been the recipient of all the soluble matter, which has percolated from the strata above, but which this stratum has arrested.

These remarks will I trust not only enable others to identify this substance, but will form also the groundwork of a theory that will explain its fertilizing power. This, however, will be better understood when I shall have presented analyses of several specimens by both the methods described in this report.

Analysis by Alkali.

No.	LOCALITY.	Water of Absorption.	Organic Matter.	Silica.	Alumina.	Oxide of Iron.	Lime.	Magnesia.	Salts soluble in Water.	Sulphuretted Hydrogen and Loss.
126	Sunderland,	3.8	3.5	64.01	15.03	12.04	0.10	1.16	0.10	0.96
130	Sheffield,	2.0	2.0	70.68	11.61	10.10	0.80	1.63	0.15	1.03
132	Amherst,	4.0	5.0	64.34	13.5	12.00	0.06	0.90	0.20	
133	Leominster,	1.5	0.5	73.31	14.25	8.14	1.00		0.10	1.2

I have been favored, also, with the following analysis of the muck sand (No. 129) from Hadley, by Dr. Dana.—100 grains, after ignition to drive off the water and organic matters, yielded,

Silica,	71.008
Alumina,	16.706
Oxide of iron,	6.202
Lime, with some sulphate of lime,	3.336
Magnesia,	1.552
Traces of manganese and potassa, and loss,	1.196
	100.

Analysis by Dr. Dana's Method.

No.	LOCALITY.	Soluble Geine.	Insoluble Geine.	Sulphate of Lime.	Phosphate of Lime.	Granitic Sand.	Specific Gravity.	Gain of 100 grains in 24 h'rs after heating to 300°.	Propor'al Absorb-'ng Power.
126	Sunderland, Ct. River,	2.1	3.0	1.0	0.9	93.0	2.57	2.1	42
127	Bradford, Merrimack River,	0.8	3.1	0.6	0.7	94.8	2.48	1.8	36
128	W. Springfield, Ct. River.	4.1	0.2	3.0		92.2	5.68	1.5	
129	Hadley, Fort River,	2.9	3.2	1.4	0.3	92.2	2.60	1.9	38
130	Sheffield, Housatonic River,	1.0	2.1	1.9	0.2	94.8	2.63	1.4	28
131	Northfield, Ct. River,	1.9	1.8	1.2	0.2	94.9	2.46	1.0	20
132	Amherst, Fort River,	6.3	0.0	1.2	0.7	91.8	2.39		
133	Leominster,	0.4	2.3	1.0	0.5	95.8	2.68	0.4	8

The specific gravities given above show that in general the density of these muck sands is greater than that of most of our soils, as we might expect from the fact that they are very sandy. The two last columns show that their power of absorbing water is small; which result also we should expect for the same reason. The power of these muck sands to retain water, we should rather expect a priori might be considerable and of some service in agriculture. So far as the trials which I have made enable me to judge, they favor this presumption, though they do not indicate any remarkable retaining power. Thus, on the 20th. of January, 1838, 200 grains of the following soils and muck sands, with 100 grains of water added, were exposed three hours to the sun, from 11 to 2 o'clock, clear, and wind westerly; and they lost as follows:

No.		Loss.	No.		Loss.
3	Alluvial Soil,	69.7 grs.	114	Sienite Soil,	54.4 grs.
4	do	69.4	115	do	66.8
5	do	70.0	116	do	57.6
6	do	68.7	118	do	61.0
7	do	71.6	119	do	63.6
15	Diluvial Argil.	66.7	121	Porphyry Soil,	66.3
16	do	69.2	123	Greenstone Soil,	64.4
18	do sandy,	78.8	127	Muck Sand,	50.0
20	do do	67.7	129	do	50.1
23	Sandstone Soil,	68.0	130	do	51.4
24	do	56.6	131	do	56.2
26	do	70.1	132	do	47.1
27	Graywacke Soil,	70.1	134	Marsh Mud,	51.0
30	do	56.3	135	do	52.9
31	do	55.8	136	do	51.9

By referring to the general Table of experiments in June 1839, upon the power of soils to retain water, it will be seen that the few muck sands there given (No. 127, 128, 129, and 130) show a power rather greater than the average.

From the water in which some of the muck sand from Sunderland had been boiled, pure ammonia, as well as carbonate of ammonia and phosphate of soda, threw down slight precipitates. Hence I infer the existence of some soluble salt of magnesia, probably the sulphate. But in no other specimen did any such result follow the application of these tests. The proper tests, however, detected in them all sulphate of lime about in the same quantity as in most of the soils. Its amount may be seen in the table of analysis of the muck sands by alkali.

The preceding analyses appear to me to show that there is no single ingredient in these muck sands that will explain their fertilizing power. But there are several circumstances that probably conspire to such a result. Most of them contain a considerable amount of soluble geine, as well as of the sulphate and phosphate of lime; and I ought to remark in respect to some of them, that they were obtained in places which are exposed to the action of water a considerable part of the time, which may have abstracted a portion of the salts and the geine; as I took them from a few inches below the surface. This was the case with the specimens from Northfield, Bradford, and Sheffield. The others were obtained at a greater depth from the surface. That, for instance, from Amherst, which yielded so large a proportion of soluble geine, was taken from an excavation just made several feet deep. This circumstance should be kept in mind, if any of our farmers should think it best to make any trial of this substance. I hope they will take care to dig to a considerable depth to obtain it, although I should presume that two or three feet would be sufficient where the muck sand shows itself on the banks of streams; and yet the constant percolation of water from this stratum may carry off some of the fertilizing matters from I know not how great a horizontal distance.

It should not be forgotten that the muck sand is the first *water bearing stratum*, we meet in descending from the surface. Consequently if any soluble salts of potassa, soda, or other fertilizing substance, should be carried down by water, percolating through the more porous layers above, they would be found in this stratum, and very probably this circumstance is important in helping us to explain the salutary effect of muck sand upon vegetation.

In addition to the above circumstances, it ought to be borne in mind that this muck sand, on account of the minute division of its parts, is in the best possible state for enabling the roots of plants to act upon and absorb nutriment. Nor should it be forgotten, that in all cases when fresh dug, these sands give off the odor of sulphuretted hydrogen; which probably proceeds from the decomposition of sulphuret of iron, or some alkaline sulphuret, by the free sulphuric acid formed in the manner described by Dr. Dana, in giving a theory of the action of clays in agriculture. Very probably this sulphuret of iron may act an important part in fertilization by these muck sands; and hence it is desirable not to use any, certainly in early experiments, which does not emit the odor above named.

These considerations, with the facts that have been detailed, excite a hope that this muck sand may prove an article of no small value as a manure. The specimen from Leominister, however, given in the preceding table, should be noticed as deficient in some points, which, according to the preceding views, are important. It has little if any soluble geine, and the salts are in small proportion. That specimen was received from Mr. Sewall Richardson, who says that it was taken seven feet below the surface, and that it has been dug three years, and exposed to atmospheric agencies. It may, therefore, have lost some of its fertilizing properties. Yet he says, "for the last four years I have applied it as manure on dry land, and find that it produces a good effect. One quart, applied to a hill of potatoes before hoeing, seems to prevent the effects of drought on the driest of our plains, and makes them yield potatoes equal to the best of our land." He says, also, that "it has as much effect on the skin, when first dug and dryed, by handling it, as lime, or ashes." It was in consequence of these statements that I subjected this specimen to analysis; although it bears but little resemblance to the muck sands in general.

Since my attention was first called to this substance by the facts that have been detailed, I

have heard so many statements of the striking effects produced upon vegetation by matters dug out of wells and other excavations, that I feel more and more convinced here is a source of fertilization for soils that has been hitherto overlooked, and which may prove of important benefit. I do not give these facts in detail, because I cannot identify the substances used with muck sand. Indeed, I am not without suspicion that my description of muck sand must be considerably enlarged to embrace all the subterranean deposites which act in a similar manner. Perhaps neither its mechanical nor chemical constitution is of any great importance, and that any subterranean deposite may be found to possess fertilizing properties, which has become the reservoir of the soluble matters that have penetrated from the surface.

When one has proceeded so far towards the extemity of Cape Cod, as to judge from the landscape around him that he has got almost beyond the region of vegetation, his attention is suddenly arrested by one or two excellent farms in the northern part of Truro, belonging to the Mr. Small: which having passed, he sees scarcely anything more of cultivation to the end of the Cape. On examination of the cliffs near Mr. Small's on the northeastern or Atlantic shore, he will find strata of blue or greenish clay. This clay appears to me to be only a variety of the muck sand that has been described; or at least, where it is washed down by the rains, it becomes muck sand: And this fact explains the fertility of this oasis. Nor can there be any doubt, but if this clay bank could be mixed with the sand in the surrounding region, it would form a soil of superior character. At present, however, the cliff is of difficult access, having long been exposed to the buffetings of the wide Atlantic. But the clay extends as a subsoil over the whole of the farms above described: and by digging a few feet, it might be obtained. The time will come, I doubt not, when this clay bank will be thus employed.

The wide diffusion of this muck sand in the state, makes me more desirous of having it tested. I have already remarked that it may be found on the banks of all our streams, which have deposited alluvium. And I doubt not it may be found in most swamps; especially those that are underlaid by clay. From the banks of rivers it might be carted at a season of the year when the water is low, since the stratum usually lies but little above low water mark: and from other places excavated on purpose, it might be obtained at almost any season. Should only a small part of the fertilizing effect result from its use generally, which the facts detailed would lead us to expect, I should still feel amply repaid for my labor devoted to the subject.

Beneath the vegetable matter in most of our swamps, there is a fine sand, quite analagous in appearance to the muck sand that has been described: and from some facts that have come to my knowledge, I suspect that this possesses, in part, at least, the fertilizing character of the muck sand. It probably contains some soluble geine and salts of lime, and sometimes gives off the odor of sulphuretted hydrogen; though perhaps this may result from decayed vegetables, as these sometimes emit an odor resembling that gas. I apprehend that this sand may be found often to possess enough of a fertilizing character to be profitably employed upon land. Benjamin Hobart Esq., of Abington, informs me, that in consequence of my remarks upon muck sand in my Report of 1838, he was led to try what he supposed to be that substance, obtained from beneath a mud swamp. He spread about as much of it as a good dressing of manure upon 10 or 12 acres of grass, and the effect in 1839 was very decided in increasing the amount of hay. I am unable, however, to give further details.

3. *Deposits from Rivers.*

Dr. S. L. Dana has furnished me with an extremely interesting communication on this subject, which I shall give in his own words: and which needs no recommendation of mine to engage the attention of the man of science, as well as the practical agriculturist.

Lowell, Dec. 18, 1839.

DEAR SIR:—I send you my remarks on the matter, suspended, or dissolved, in the waters of Merrimack river. This matter is interesting both to the geologist, and to the agriculturist. To the former as a question in geological dynamics, and to the latter, as the source of the fertilizing power of overflowing streams.—I am indebted to the assistance of Mr. James B. Francis, Civil Engineer, attached to the Locks and Canals in this place, for the computation of the quantity of water flowing in Merrimack river. The daily register of the height of the river, kept under his inspection, added to his minute and accurate measurement of the daily volume of water, has enabled us to approximate the actual amount of effect, due to a portion of one of the causes of geological change, in present operation, with a degree of certainty, which, if not entirely satisfactory, is more accurate, than has heretofore been attempted. Ordinarily the Merrimack river is clear and transparent, having a slight yellow brown tinge, by transmuted light. Great rains produce turbidness. The water becomes clay colored. During these periods, I have daily taken out 20 gallons of river water, and after 24, to 48 hours repose, in a vessel about 18 inches deep, the water was decanted, the sediment collected on a filter, dried at 300° F. and weighed. From these data, and his own measurement of the quantity of water, Mr. Francis has calculated the following table, showing the amount of matter borne seaward, by Merrimack river in 1838, and during an unusually high fresh in 1839.

Date		No. of Days.	Quantity of Water in cubic feet.	Grains of suspended matter in 1.cubic foot.	Total suspended matter in pounds avoirdupois.
From	to				
1838, May 5.	May 9.	5	9.630.316.800	3.583	4.929.346.
" 26.	" 29.	4	5.738.428.800	19.531	16.011.036.
June 5.	June 9.	5	5.150.562.400	3.366	2.475.2¾6.
Nov. 9.	Nov. 12.	4	13.105.843.200	25.808	48.319.371.
" 13.	" 17.	5	8.690.889.600	.112	139.054.
Total		23	42.316.040.800		71.874.063
1839 Jan. 28.		1	4.685.817.600	30.483	20.405.397
" 29.		1	3.633.526.400	22.815	11.855.023
" 30.		1	1.818.115.200	12.006	3.118.327
31.		1	794.966.400	4.226	479.932
" Feb. 1.		1	529.977.600	1.481	112.128
Total.		5	11.466.403.200		35.970.807

Leaving out, adds Mr. Francis, the 23 days given above, I find the average flow of the river for the remainder of 1838, about 6000 cubic feet per second—giving a total discharge for 342 days of 177, 282, 800, 000: cubic feet.

The question, whether the year 1838 is an average can only be determined by continued observation. I am still directing my attention to this point. I incline to the opinion

that 1838, is a fair average year. It is seen from the table that during the great freshet of Jan. 7, 1839, nearly one half as much matter was borne downwards in 5 days, as during the whole year of 1838. This was the highest freshet observed for the last 6 years. The table above gives the actual amount only, which would be deposited by a few days repose. This amount is interesting only to the agriculturist, whose lands are fortunately irrigated by these periodical overflows. To estimate the actual geological effects, we must add to the above amount a finer deposite which longer repose precipitates from the waters of a freshet, and the matter chemically solvent both during a freshet and ordinarily, and also the amount of matter ordinarily suspended. This last quantity is 0.100 of a grain per cubic foot of water. After the clay colored matter has settled, a finer white deposit occurs in a few days. It is so fine as to pass through filtering paper. It gives to the water a slight milky look viewed in a tube of 3 inches diameter. It is long subsiding, and gradually collects in fine white flakes, which precipitate, forming a skinny lining on the bottom of the vessel. This membraneous lining by some months exposure to air, becomes dark olive green colored. It consists chiefly of silica with an organic acid. It ought not all truly to be called suspended matter—though for the present purpose I so estimate it. The skinny deposit, which occurs, *lichen* like on all substances long time under the river water seems of similar nature.—I may remark here, that the clay colored deposit occurs in substances in the water, whatever their position, slanting, upright or flat. Its slimy nature causes it to adhere whatever the position, and when collected from the bottom of a tub it may often be rolled off in a continuous sheet, like tough wet paper.

The water of the freshet of 1839, decanted from the sediment deposited in 48 hours, was allowed to repose one month: it became perfectly clear,—though slightly milky at first, and the amount of the fine white flocculent precipitate, which now formed a skin, was in one pint 0.3857 grain or per cubic foot 23.0015 grains. No more deposit occurring after 7 days repose, the water was evaporated to dryness. During this operation brilliant scales began to form and a filmy white mass, with a brown tinge remained, weighing in one pint of water 0.6172 grain, or per cubic foot, 36.776 grains. This amount is less than that ordinarly in solution; for by long exposure, a portion of the chemically solved matter is decomposed, or forming new combinations was precipitated. The amount of matter ordinarily held in solution in the river water is 0.82 grain per pint, or 48.86 grains per cubic foot. If now we add to the matter suspended in the water in

the 23 days by the above table,	71.874.063 pounds.
The finer deposite in 23 days,	139.280.225 pounds.
The matter chemically solved in 23 days,	221.853.831 pounds.
Matter ordinarily suspended in 342 days,	2.532.611 pounds.
Matter chemically solved in 342 days,	1.242.803.080 pounds.
We get the total for year 1838,	1.678.343.810 pounds.

The mind cannot conceive this amount. We may form a more precise idea of its extent by supposing the whole to be anthracite coal. At the present rate of coal consumption in the Merrimack Print works, 5000 tons per annum,—the above would then last 167 years.

Chemical Constitution of the Suspended Matter.

I collected in 1837 a quantity of this substance, deposited on the rocks at Pawtucket falls in Lowell. This was analyzed by drying at 300° F. then calcining to destroy organic matter, fusing with alkali, and separating the constituents in the usual way. I add the analysis of a similar deposit, from Connecticut river, collected in 1837 from the rocks just above the bridge between Greenfield and Montague. In both, traces of mosses, vegetating were evident to the eye.

	Merrimack River.	Connecticut River.
Organic matter, geine,	2.500	2.640
Silica,	77.530	77.397
Alumina,	8.650	8.325
Oxide of Iron,	9.500	8.848
Lime,	.535	.767
Magnesia,	.103	
Sulph. acid, Phosphoric acid,		
Traces of potash and loss,	1.182	2.023
	100.	100.

The finer deposit occurring after a month's repose, gave a constitution similar to the above: and the water evaporated, after all mechanically suspended matter had subsided—gave, in one pint, 0.6172 grain, composed as follows :—

Organic matter,	.3086
Lime, with some Sulphate of Lime,	.1928
Silica,	.1155
Loss,	. 003
	0.6172.

The organic matter exists chiefly under those forms of geine called crenic and apocrenic acids. It readily solves in water, with a brown color; decomposes some metallic salts, and combines with lime and moist hydrate of alumina. Its acid action is the source of the rapid solution of lead in Merrimack water. Crenate of iron, and alumina, is deposited rapidly on iron tanks and pipes exposed to the constant running of the river water. I have seen this compound deposited 1-2 inch thick in two years in an iron tank, on its upright sides; and mamillary concretions, like large almonds, covering large patches of a cast iron pipe, which had been in use a few years only. These concretions will doubtless in time accumulate, and finally obstruct the passage of water though iron pipes used for its conduit.

The constitution of the deposit, collected on the rocks of the river, is analogous to your "*muck sand.*" The organic matter, which is geine, is the source of the vegetating power, which the sand gives to seeds. In many places, where the alluvial deposit forming the basin of Lowell has been cut through, layers of "*muck sand*," from 2 inches to several feet in thickness have been exposed. They are separated by strata of coarse sand and gravel. When this section has been sometime exposed to air, the "*muck sand*," can be distinguished at a great distance, by green bands, a color derived from the infinity of small plants vegetating and luxuriantly growing in the stratum. This is certainly a very strong proof of the agency of geine, if not of its actual necessity to growing plants. Whether we believe with Fuchs that geine, which he calls humus, is among the original and earliest formations, or with others, that it is of later origin, arising from organic decomposition, it is evident, that being so abundantly diffused in river deposits, which ultimately become sea deposits, it is the source of the carbon, and also of the ammonia, which late experiments have detected in primitive rocks. In the great series of geological changes, these sedimentary deposits, now taking place, will doubtless arise in new forms, in mica, and clay slate, perhaps of rocks of crystalline character. But let us leave speculation and attend to the

Agricultural Value of River Deposits.

All experience teaches the fertility of soils periodically overflowed by the turbid waters of rivers. Perhaps from the similarity of chemical constitution of the deposited matter, with " muck

sand," the reason of its fertilizing power will be obvious to the readers of your report on that substance. We can refer the fertility given by the overflowing freshets only to the geine, salts of lime, and beautifully fine state of the silicates which make up the bulk of the deposit. The silicates being so exquisitely divided are readily decomposed by the action of the air, the carbonic acid eliminates potash and soda from the silicates, just as the same action decomposes the silicates of alkali in spent ashes, peat ashes, and greensand. Indeed I have no doubt, that the green sand, which you sent me, had lost its potash from this very cause. Our granite, particularly, that most abundant in felspar, should, if finely pulverized, act like green sand. The river deposits, containing silicates of alkali finely levigated, and exposed to the carbonic acid of the air, and the electro-chemical agency of growing plants, are rapidly decomposed. The alkali is evolved and solves the geine and geates, which make up no small portion of the deposit. I have subjected several portions of these deposits, collected at different times, to Agricultural analysis. The results are shown in the following table.

	Sol. Geine.	Insol. Geine.	Sulph. Lime.	Phos. Lime.	Silicates.	
Connecticut River. off rocks.	2.30	1.70	.64	.46	94.90	
Merrimack River, Spring of 1837. off Rocks.	2.50	1.10	.90	.60	94.90	All give up to water Sulphate and geate of Lime.
" Fall of 1837. off Rocks.	2.06	1.86	.74	.90	94.44	
Deposit from Freshet of January, 1839.	5.40	6.50	2.34	1.20	84.56	Oxide Iron, Alumina, Magnesia, Sulph. and Phos. acids in the soluble geine are 2.34
Deposit, July, 1839.	8.80	6.30	3.10	.60	81.20	Oxide Iron, Alumina, Magnesia, Sulph. and Phos. acids in insoluble Geine, 1.50.

The true agricultural value is shown by the deposit from the freshets of January and July, the others being coarser sediments, that is more sandy. With great respect,

SAMUEL L. DANA.

V. AMENDMENT OF SOILS.

It may perhaps be expected that I should, before I close the subject of soils, endeavor to show how the defects of the different geological varieties of soil in Massachusetts may be remedied, in addition to the more general views, that have been presented on the subject. But in most cases I doubt whether chemistry or geology can add much to what the farmer has already learnt from experience; and therefore the subject, as I conceive, hardly falls within my department. I shall, however, add a few remarks respecting the amendment of a sandy soil; since a large part of four counties in the state, viz. Plymouth, Barnstable, Dukes, and Nantucket, are on this account at present regarded as sterile beyond reclamation.

It is indeed true, that lands so barren as those above referred to, can be brought into a fertile condition only with great labor and expence. It is however, similar lands on which green sand in New Jersey and other states

has exerted a remarkable transforming influence; and should any of the green sand of Massachusetts prove serviceable, its use would probably be the most economical mode of commencing the work of fertilization. But a surer plan is to follow the methods adopted with so great success in such a country as Netherlands; where the most barren sands have been extensively converted into fruitful fields. Where such a soil is underlaid by clay, or loam, even if it lie at the depth of several feet, an obvious preliminary is to bring a large quantity of the subsoil to the surface; and then to introduce into the mixture a sufficiency of geine. But even where no such subsoil exists, the case is not a hopeless one. The first step is to plant the surface thickly with some plant that will grow upon it; and as this decays, it will form geine for future use. Ere many years, enough nutriment will be collected to form a soil, in which useful plants will grow: and when once brought into this state, it is, taking all things into the account, one of the best of soils. The Belgic farmers commence with broom, pines, &c. In Massachusetts beach grass (*Arundo arenaria.*) is usually employed to fix the sand: but I doubt whether this is very well adapted to form a soil; since it decays so little. I noticed that in the old fields upon Cape Cod, which had been cultivated until the geine was nearly exhausted, that large patches of the *Hudsonia ericoides*, or *false heath plant*, and of *H. tomentosa*, or *poverty grass*, were frequent. These form a thick mat upon the soil, and cannot but collect some vegetable and animal nutriment. May they not be made serviceable in the way that has been described.

When I visited Provincetown nine or ten years ago, scarcely a square rod of land was attempted to be cultivated in the whole town. But on a recent visit, I perceived several gardens of considerable extent; containing a good crop of vegetables, and of excellent quality. Mr. Lathrop in particular, the enterprising proprietor of the hotel there, has prepared an excellent garden, chiefly by manure and the mixture of the salts of lime and magnesia, which are obtained in great abundance from the extensive salt works in that place: and which are just coming into use on the Cape as a manure, and will undoubtedly prove serviceable if used only in small quantities. Mr. Lathrop thinks that garden vegetables may be raised there a fortnight earlier than in the region around Boston; and that hence it may be an object to raise them for Boston market. This hint may be worthy the consideration of the farmers on other parts of the Cape. Mr L. also showed me a swamp of considerable extent, probably a peat swamp, which he proposes to convert into arable land, by bringing over it a quantity of sand from the adjacent hills. I hope this experiment will be tried, not only there, but in other parts of the sandy region of Massachusetts, where such swamps are common. For although expensive at first, land thus formed must become exceedingly productive and valuable.

But the most striking example which I have met with showing how productive the most barren soil may become, was pointed out to me by James Small Esq. of Truro on Cape Cod. In passing down the Cape, long before

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one reaches his farm, most of the country appears excessively and hopelessly barren. His farm, however, is based upon blue clay, and forms a fruitful oasis amid the sandy waste. But between that spot and the end of the Cape, little meets the eye, out of the salt marshes, but white drifted sand, save here and there a small patch of beach grass, or pine shrubs, or poverty grass. Yet three miles beyond his house, Mr. Small took me to a field of several acres, where the soil appeared of a dark color and abounded in fragments of shells, particularly the round clam, or *quohog*. So productive was this soil, that 50 bushels of Indian corn had been raised upon an acre without manure! The following analysis shows us at once the secret of this fertility.

Reckoning the fragments of shells as carbonate of lime, we have in 100 parts:

Carbonate and Sulphate of Lime,	21.30
Phosphate of Lime,	0.35
Soluble Geine,	3.75
Insoluble do	1.50
Silicates,	73.10
	100.00

After the salts of lime and the geine were separated, the residue consisted of nothing but the common white sand of Cape Cod. This geine and these salts, therefore, are all that is necessary to convert other sandy fields on this Cape into fertile spots.

I find these broken shells to be somewhat frequent on the Cape; and the general impression is, that they were brought into their present situation by the Indians, that the animals might be extracted for food. But their great extent leads me rather to suspect that such spots were once the residence of these animals, when beneath the sea: or rather, that they were once the shores of the ocean, and that the waves drifted the shells thither.

Concluding Remarks upon Soils.

I might proceed to discuss numerous other points respecting the chemical and geological character of soils and cultivation. But really, I do not feel prepared to throw any new light upon them; and will not therefore occupy space and time with detailing what is already described in various authors, such as Davy and Chaptal. The time and labor which I have already devoted to this subject, are more than I should have felt justified in bestow-

ing, were it not of the first importance. Those only who are practically familiar with analytical investigations, can correctly judge how much time and labor it has cost me to obtain even the imperfect results that have been given. In analysis a result which is expressed by a single figure, often costs days of careful labor to obtain.

It will be seen that a considerable part of what I have presented on this subject (and the same remark will apply to much that follows on economical geology,) consists of suggestions. The many new views, which through the aid of Dr. Dana I have brought forward, and the new substances to which I have directed the attention, rendered such a course necessary: since it was impossible for me to prosecute the requisite experiments for testing the truth of my convictions. Of course, others who have an opportunity to make such experiments, will place so much confidence in my suggestions as the reasons offered to sustain them, will in their opinion justify. Should any of these suggestions be carried out into practice and produce valuable results, my object will be attained, even though they should require such modification, that the original author shall be forgotten and unnoticed.

I confess myself influenced in these researches by an ambition to point out some of the means, whereby two or more blades of grass, or ears of corn, may be made to grow where one grows now in Massachusetts. And this I sincerely believe to be an attainable object. More and more thoroughly am I convinced, that it needs only patient industry—such as has ever been the glory of New England—and an intelligent and judicious application of our internal resources, to convert five sixths of the surface in Massachusetts into fertile fields. The idea that a large part of our soil is absolutely unfit for cultivation, and incapable of improvement, which has discouraged so many of our young men, and driven them away from their paternal homes, is contradicted at every step of a fair investigation of the subject. As I have approached one of our beautiful villages, and seen all around it such prolific crops, I have frequently enquired why such a difference exists between the fertility there, and the wide region over which I have been passing since I left the last village? For in the natural character of the soil I could perceive no essential difference. The conclusion would be, that cultivation has made all the difference. And yet, in that village are probably many young men who feel as if all the valuable land around them were taken up, and that they must seek their fortunes in some distant and more fertile region. It is true that our soil will yield to nothing but persevering industry and skill. But the habits of diligence and endurance which will be acquired in subduing it, are of far more value to the possessor, both for the promotion of his fortune and his happiness, than the richest manor that yields almost spontaneously. The very object of Providence apparently in giving us a soil by nature comparatively sterile, yet capable by cultivation of yielding an abundance, was to call into exercise that

industry and energy, without which man becomes a mere drone, or the miserable slave of indolence and the low appetites.

I do not doubt but the Government and every intelligent reflecting citizen will feel the vast importance of energetic efforts to improve our soils so that they may sustain a larger population. This is the only way to check the tide of emigration that sets so strongly to the great West. For if our sons can be made to see the soil of New England doubling its increase, as I verily believe they might in one or two decades of years, the rich alluvia and prairies of the West will not be able to draw them away from the graves of their fathers; especially if they learn that those fertile regions will at length become exhausted of their geine and salts, and then will probably require as much labor to cultivate them as the soils of Massachusetts.

Some, however, may contend, that it is more important to transfer the New England character to the unsettled West, than to multiply our numbers and wealth at home. But the history of the world leads us to fear, that New England character cannot long be preserved except upon New England soil; or upon a soil that requires equal industry for its cultivation. Place New England men where the earth yields spontaneously, and the locks of their strength will soon be shorn. If we look over the map of the world, and the history of the past, we shall find as a general fact, that the brightest exhibitions of human character have been made, in regions where nature has done less, but art and industry more. If, therefore, we wish to increase the moral power of New England, it must be done by improving her soil, and increasing her resources and her population. If these views are correct, which I acknowledge do not fall in with the prevailing notions, they furnish a new stimulus for vigorous effort in the improvement of our soils.*

Note on the Nature of Geine.

Having transmitted a proof sheet to Dr. Dana, of my remarks on the nature of geine, with Dr. Jackson's method of analysis, he has been led to send me his views on these subjects more fully than ever before. His letter contains so fair and masterly a defence of his views concerning the nature of geine, that I am unwilling to withhold it; especially as it seems I have misapprehended some of his opinions on that subject. And since Dr. Jackson seeks only truth, like every man of genuine science, he will not, I trust, object to so candid an examination of his opinions.

* This may be the best place to mention, that the first column of the Table showing the power of soils to absorb oxygen on page 63, should have placed over it the words, *Per Cent*: the second column, the words, *Cubic Inches*: and the third column, the word, *Grains*.

Lowell, June 22. 1840.

Dear Sir:—You know I have for some time meditated a new analysis of geine. My engagements have prevented my undertaking this point, in season for your report, and I very much doubt whether such an analysis as I can ever execute, would throw any new light on its constitution. Perhaps in the present state of the opinions respecting its nature, my analysis would be considered ex parte evidence. I am satisfied with the results already obtained by others. From the days of Vauquelin, who first noticed ulmin, to the present time, this substance has been investigated by the most distinguished chemists, under the name of ulmin, or humus, or geine. These are convertible terms, they mean one and the same thing. Its atomic constitution was partially settled by Sprengel, and more fully by Boullay Jr. The discrepencies in the results, led Berzelius to remark, that the whole subject required a new investigation, though Dumas expresses his confidence in the results of Boullay. His statements have since been verified by Malagutti. Thompson, in his Organic chemistry, refers to Malagutti's paper, as published in *Journ de Pharm.* xxi. 455. and Dumas, in his 5th. Vol. refers to Malaguti's *observations inedites.*

Malagutti has obtained ulmic acid in distinct crystals. By boiling these in weak acids, a black substance is deposited, which he calls ulmin, identical in its composition with the acid. Once and for all, I consider, ulmin, humus, geine, ulmic, humic and geic acid, one identical substance; whether neutral or acid its constitution, ever one and the same, subject to the great law of organic chemistry, that proximate compounds act as simple elements.

Boullay's analysis of geate of copper, on which he placed most reliance, is the following:—

Geine,	89.5
Oxide of Copper,	10.5
	100.

Malagutti's result agrees with this, more nearly than is usual in minute analysis, and is as follows:—

Geine,	89.2
Oxide of Copper,	10.8
	100.

Deducing from these analyses the atomic weight, we get from Boullay, 42.61
from Malagutti, 41.29

83.90 the mean 41.95.

The result of the analysis of geic acid, by oxide of copper is by

	Boullay,	Malagutti,
Oxygen,	56.7	57.48
Hydrogen,	4.81	4.76
Carbon	38.49	37.36

Deducing from these the atomic constitution of geine, we get from Boullay, with whose ratios Malagutti agrees,

Oxygen,	16.	atoms	= 16.
Hydrogen,	16.	"	= 2.
Carbon,	32.	"	= 24.
	64.		42. atomic weight

Now the mean of the result, 41.95, from the analysis of geate of copper given above, differs 00.05 from the theoretical result. We may safely take, therefore, 42. as the atomic number of geine.

A substance found by different observers so identical in composition, by actual analysis, whose theoretical confirms its analytical constitution, which forms definite compounds, and whose history and properties are better understood than a large proportion of the objects in organic chemisty, may well be considered a definite chemical compound. That it is so, is believed by all chemists, except Raspail, whose principles would equally reduce the larger portion of organic substances, to carbon and water; and Dr. C. T Jackson, who reduces geine into a mixture of crenic and apocrenic acids. Others have admitted these acids in combination with geine, in soils. Berzelius their discoverer, and to whom we are indebted for all that is known of their history, years ago said, that crenic and apocrenic acids existed in soils, in small quantity; and moreover states, that these acids are among the general products of putrefaction. The doctrine then, that they are found in soils, is not the doctrine of yesterday nor of to day—it is no new thing; but the doctrine that geine is a mixture of these acids, that geine has no independent existence, is new; and coming from a source, commanding our respect, requires a careful consideration. The various opinions which have been formed on the subject of geine, owe their existence in part, to the varied means which produce this substance. It comes from organic matter, by putrefaction, by the action of acids and of alkalies, caustic or carbonated, by the action of alkaline earths, by alumina, by metallic oxides, acting on organic matter, especially when assisted by heat, and as a general law, we may say that all substances, oxidating, and gently acting on organic matter, produce geine. It is produced by fire, by heating or roasting organic matter, and hence its abundance in soot, in crude pyroligenous acid, in charcoal, and baked wood. It is found in carburet of iron; and cast iron, treated with acids, leaves an insoluble residue, having the properties of geine. Of all the agents, which thus change organic matter into geine, the action of the alkalies and of the alkaline earths is most powerful: next to them ranks alumina, which is little, if at all inferior to lime, when assisted by growing plants. It is the decomposition of the aluminous silicate, by living plants, which lets loose the alumina, to convert insoluble into soluble geine. But to return, the mode of acting here is in many cases purely "*catalytic*," the action of presence,—the same elements re-arranged, a new order takes place,—while in other cases, a part of the original compound is removed—new substances are produced. In whatever way we may produce the proximate principle geine, whose definite constitution we see has been so well determined, it is not at all probable, that it proceeds, *per saltum*, from organization to its atomic constitution. There exist, doubtless, intermediate states, other compounds, which chemistry has already, or will hereafter detect; forms of geine so to speak.—In this class, I include crenic and apocrenic acid. Nor can we determine whether these arise from a catalytic change in geine, or whether they are formed first, and then unite to produce that definite compound. But the properties and actions are so very distinct from those of geine, that the last cannot be owing to a mere mixture of thetwo first. From the small quantity in which they accompany geine in soils, it is probable that they derive their origin from a change in the elements of that substance; and if ever geine, has been *wholly* reduced to crenic and apocrenic acid, I think it is no difficult matter, to show how this result has been produced by the agent employed, and by the manipulation. Cases analagous are familiar to all chemists, and the very ease with which crenic passes into apocrenic acid, may help our conceptions of the possibility of a mere new arrangement of the elements of geine,—an arrangement producing two well defined acids, being considered as the separation of those which previously were only mechanically mixed.—As evidence of the evanescent nature of crenic acid, it is well established, that its solution in water, by simple exposure to air, becomes apocrenic acid: hence it name: its existence, as Berzelius says, depends on crenic acid, just as *apo*-theme, depends for its existence on a solution of organic extract in water. Without crenic there can be no apocrenic acid. These acids have been separated. Their insulation is one of the most difficult of chemical operations, requiring not one, but several solutions and separations by sulphureted hydrogen before we can estimate their quantity, or be assured if their purity. Separated, their characters are as follows:—Both resemble vegetable extract:

Crenic acid.	*Apocrenic Acid.*
Color yellow,	Brown,
Transparent,	
Amorphous,	Amorphous,
Taste acid, then astringent	Astringent,
Excessively soluble in water and	Slightly soluble in water.
" " alcohol	Slowly soluble in pure alcohol
	Solution in water, precipitates by Sal. ammoniac in flocks.

Crenates.	*Apocrenates.*
Of alkalies, like yellow extracts, and very soluble in water, and weak alcohol.	Of alkalies, black friable masses; in water a dark soluble brown color.
Of lime, neutral, soluble in water, subsalt, insoluble.	
Of magnesia, easily soluble in water.	Of alkaline earths, solve in water, yellow colour. The subsalts quite insoluble.
Of alumina, neutral insoluble in water: supersalt, soluble.	Of alumina, neutral, insoluble: supersalt, soluble in water.
Of iron, soluble in water.	Of iron, protoxide, soluble in water: peroxide, insoluble in water.

From the statement I have already made of the elements which enter into soluble geine, it will be seen that a small part only of soils exist, as a geic salt. The phosphoric acid I have ennumerated among these elements, confining the term "soluble geine" in that case to all which an alkali dissolved. The phosphoric acids proceeds from a partial decomposition of phosphate of lime, or subphosphate of alumina. It is not an element of geine. The iron and alumina are dissolved as salts of geine. We conclude that the greater part of the geine of soils exists uncombined. If this substance, as it exists in soils, is only a mixture of crenic and apocrenic acids, then, from the established properties of these acids and their salts, this result must follow. *The soluble organic matter of soils ought to be completely solved by water and alcohol.* No other agents are required to detect not only the existence, but the total amount of these acids, to determine in fact the amount of soluble geine. Simply boiling the soil in water should extract all the crenic acid. "It is excessively soluble in water," says Berzelius—so soluble, that the water of the Porla well, the source whence this acid was first obtained, is colored brown by it. Pure alcohol, will then dissolve all the apocrenic acid; and we may thus at once ascertain the amount of these acids. Admitting the properties of crenic and apocrenic acid, I do not see, how we can escape this conclusion. Nor will it alter the case, if it be said that the acids are combined with the bases of earths and oxides. We still are driven to the same conclusion. Now this is a result, which I presume the propounder of this doctrine of the mixed nature of geine, will not admit. He knows how very trifling is the proportion of organic matter, or its salts which yield to alcohol, or to water. I do not mean to deny that this little is crenic or apocrenic acids or their salts. Nor will the advocates of the doctrine, deny, that all the crenic acid, will, by exposure to air, pass into apocrenic acid. If then, geine be a mixture of acids, and is insoluble in the agents which act easily on these acids while separate, we may reasonably conclude that the elements of these acids, have arranged themselves anew, entered into a *true chemical combination*, to form geine, a definite proximate principle, whose separate, independent existence, whose properties, combinations, and uses, are as well established as any facts in chemistry.

Finding then, that the action of water and alcohol on the geine of soils is wholly different from that which ought to ensue, if it is a mixture of crenic and apocrenic acids, other agents have been employed to effect their separation. Now these agents, are precisely those, which we have enumerated above, as having the power to alter the arrangement of the elements of organic matter, or of geine; developing either acid properties, without altering its constitution, or re-arranging its elements, without addition, or subtraction. The long and repeated digestion in carbonate of ammonia, has *produced* not *educed* crenic and apocrenic acids.—We are not informed of any other result, of any other product: no evolution of gas, indicating that any decomposition has occurred. From the acknowledged chemical tact of Dr. C. T. Jackson, we infer, that geine has afforded him only crenic and apocrenic acids. That these are the products of his process can then be easily understood.

The atomic weight of geine we have shown is 42. This number differs but little from the sum of the weight of two atoms of crenic acid, and one atom of apocrenic acid. Berzelius determined the atomic weight of crenic acid to be, 13.50
of apocrenic acid, 16.50

then 2 atoms crenic $= 13.50 \times 2 = 27.$
1 atom apocrenic 16.50

43.50

Which differs only 0.89 from Boullay's number for geine, deduced from his analysis of ulmate of copper. But allowing the crenic acid, to be 12.75 we have then 2 atoms $= 25.50$
1 atom apocrenic $= 16.50$

42.00

And that 12.75 is probably the true number, will appear from re-arranging the atoms of geine, so as to constitute two atoms of crenic and one of apocrenic acid.—I have met with no analysis of the atomic constitution of these acids,* but taking their atomic weights, as above, and the result of Dr. C. T. Jackson, that geine is wholly separated into these acids, then the number of the atoms constituting their weight, is as follows:—

	Crenic acid.	Apocrenic acid,
Carbon,	11. = 8.25	10 = 7.50
Hydrogen,	4. = .50	8 = 1.
Oxygen,	4. = 4.	8 = 8.
	12.75 × 2 +	16.50 = 42

The number of atoms in 42 geine is 64. as above:
and we have 1 atom geine $= C.^{32}\ H.^{16}\ O.^{16}$

*(Note.)—Hermann has given the following as the constitution of the crenic, apocrenic, and ulmic acids. (*American Journal of Science, &c. Vol.* 36, *p.* 369).

	Crenic.	*Apocrenic.*	*Ulmic.*
Carbon,	535.0 (= 7 atoms.)	1070.1 (= 14 atoms.)	6190
Hydrogen,	99.8 (= 16 ")	87.2 (= 14 ")	431
Nitrogen,	88.5 (= 1 ")	265.5 (= 3 ")	1105
Oxygen,	600.0 (= 6 ")	300.0 (= 3 ")	2274
	1328.3 (combining weight)	1722.9 (combining weight)	10000

It is hardly necessary to observe, that these results confirm the suggestion of Dr. Dana in the text, that crenic and apocrenic acids were not probably so constituted, as to be entirely converted into geine without an excess of any of the ingredients. E. H.

Which resolved into

2 atoms crenic acid,	=	$C.^{22}$	$H.^{8}$	$O.^{8}$
1 atom apocrenic acid	=	$C.^{10}$	$H.^{8}$	$O.^{8}$
form one atom of geine	=	$C.^{32}$	$H.^{16}$	$O.^{16}$

It may be said, that it may be proved, that my statement of the atomic constitution of these acids is not confirmed by analysis. So much the better. That will prove, that geine cannot be a mixture of them. Though these elements theoretically admit of this arrangement, it is not at all probable, that nature forms crenic and apocrenic acids, out of which to form geine, by their complete chemical union; still less is it probable, that she merely mixes these acids. The constitution of geine is too firmly settled, to allow us to believe, that it is a haphazard mixture. The evidence of the existence of a simple proximate principle, geine, is rather strengthened, than weakened, by the above view of its probable theoretical changes. And as Dr. Jackson states that he has actually separated geine into two acids, he has furnished new and unquestioned proof of the existence of that principle. If the sum of the weights of his crenic and apocrenic acids equals the weight of the organic part of his soluble geine, he furnishes the highest evidence we can have, of the separate, independent existence of that element. I believe he has seen all that he states, and I must ask him to believe that the conclusions to which we have arrived, respecting the nature, constitution and properties of geine, are equally founded on experiment. While I thus freely admit the results he states, I express my conviction, that what he has seen, he has produced, that he has merely re-arranged the elements of a well known, definite compound, by the long continued action of ammonia. Such changes may not be readily comprehended by the majority, into whose hands your report may fall—all however now a days understand that there is such a thing as carbon, such elements as oxygen and hydrogen, which last by their union produce water. Now it is evident, by a glance at the above arrangement of the elements of geine, and crenic and apocrenic acids, that these are each and all, resolvable into carbon and water. We may as well deny the existence of crenic and apocrenic acids because resolvable into carbon and water, as to deny the existence of geine, because resolvable into crenic and apocrenic acids. A glance too at the above arrangement, will show us how crenic becomes apocrenic acid by simple exposure; for by absorbing oxygen, each atom parts with 6 atoms carbon, and then 2 atoms crenic form one of apocrenic acid; for,

	Oxygen.	Hydrogen.	Carbon.
2 atoms crenic acid,	11	4	4
	11	4	4
	22	8	8
Deducting 12 Carbon,	12		
form 1 atom apocrenic,	10	8	8

It is this change, which may account for the great evolution of carbonic acid, which attends the exposure of geine to air. The alkaline, earthy and metallic bases of the silicates of soils, as they are eliminated by the decomposing action of growing plants, all effect catalytic changes in geine. But without these, geine itself is decomposed by air and moisture, evolving volumes of carbonic acid. It becomes in every, and the widest sense, the food of plants, whether we consider it taken up as a simple solution of geine, or geates, or as a prolific source of carbonic acid. I do not however consider carbonic acid as vegetable food, or as playing a very important part in the nutrition of plants. Jablonski tried to verify the idea of Raspail, and to determine how much is due to the action of carbonic acid. The whole series of his most carefully conducted experiments, feeding plants only on carbonic acid and water, lead to this conclusion;

that carbonic acid and water do not sustain plants, after the vegetable nutriment deposited in albumen or the cotyledons has been exhausted. I did never suppose, till I learnt it from you, that any one could have believed that I denied that plants absorb nourishment from air. Speaking wholly of soils, and that by letter, I confined my remarks strictly to the nourishment derived from the earth. But extending the remark to air, geine is the great source of carbonic acid even then, and as far as carbonic acid is absorbed by the roots of plants, is perhaps its only source. I go farther. I believe that geine was, before organic matter, an original formation, dating its birth from the dawning of time, when oxygen and hydrogen and carbon were created. I believe it to have been an original formation, the source whence were nourished the gigantic plants of coal formations, and of itself, forming a large part of such deposits. Hence we find little or no alkalies in our analysis of coal—a little silica, iron, lime and alumina only having been formed as geates, in this early age.

I have not thought it worth while, to go into an examination of the practical value, to agriculture, of the doctrine of the mixed nature of geine. If it has any value, it depends entirely on showing that crenic and aprocrenic acids require different treatment from geine, and on determining the proportion in which these acids exist in soils The first has not been done, the last never will be effected. It cannot be. We see these acids passing from one to the other state even during our manipulations; how then can we determine in what proportions they existed in the original soil? It may be said, that we can estimate them all, as crenic acid, as Berzelius has, in his analysis of the water of the Poria well. In this case, so far as agriculture is concerned, we may call them geine.

With the highest regard, I am

Your Friend and Servant.

SAMUEL L. DANA.

Prof. Hitchcock.
Amherst.

P. S. I do not ordinarily use the oxygen scale. The statement above being chiefly derived from Dr. Thompson, I have employed his numbers for your convenient reference.

VI. FOSSIL FUEL.

Next in importance to the means of improving our soils, I have regarded the discovery of fossil fuel; that is, fuel dug out of the earth, and resulting from vegetables which have been buried there in former times; and therefore, I have examined with no small care, every spot where such discovery seemed likely to be made. When I prepared my first Report, I confess my xepectations were not sanguine that Massachusetts contained within her bosom any extensive deposits of coal; though aware that not a little peat might be found. But since that time, the enterprise and industry of some of our citizens have put quite a different aspect upon the subject so far as coal is concerned; and I have made such extensive inquiries respecting peat, as leads me to suppose its quantity in the state has been much underrated. I will now proceed to give such details as will enable the Government to form an opinion on the subject.

Of fossil coal there exists three well marked species. The first is anthracite, or stone coal, sometimes called anasphaltic, because destitute of bitumen, and therefore burning without flame: though the anthracite of this country gives off a feeble flame, resulting from the combustion of hydrogen, which is evolved from its combination with the carbon; or more probably from water. The second variety is bituminous coal; so called because it contains bitumen. This burns with a white or yellow flame, and is the kind of coal

most commonly used; except in this country, where anthracite is most extensively employed. The third variety is lignite; which is a more recent kind, not yet entirely carbonized or bituminized. Hence it is sometimes called ***brown coal.*** As fuel it is of little value; but has been used in some parts of Europe.

We have all these varieties of coal in Massachusetts; and I shall now proceed to describe all their known localities.

Anthracite of Worcester.

Only two large deposits of this species coal have yet been discovered in Massachusetts, one in Worcester, and the other in Mansfield. Several important localities, however, occur on the borders of the state within the limits of Rhode Island, which I shall notice more particularly farther on. But I shall begin with the Worcester deposit, because this is obviously older than those of Mansfield and Rhode Island.

By some of our earlier geological writers it was asserted that the Rhode Island coal deposit was connected with that in Worcester. But a reference to the geological map will show, if I have not been grossly mistaken, that no such connection exits: that in fact the different deposits are in very different formations. While those of Mansfield, and Rhode Island are in rock certainly not older than the graywacke, that in Worcester is in a bastard kind of mica slate; passing sometimes into quartz rock, and at others into argillaceous slate. No trace of organic remains has been found in this rock, while the other abounds in vegetable impressions and petrifactions. The character of the coal corresponds to these differences in the rocks. That from Mansfield and Rhode Island resembles very much the anthracite of Pennsylvania; except that occasionally it is more glazed with plumbago; while that from Worcester is often converted into plumbago. In fact, a good deal of it is ground up and employed for some of the same purposes as black lead. Its aspect is much more stoney than that of Mansfield, and its specific gravity is 2.12; while that of Mansfield and Rhode Island, is 1.75: and that of Pennsylvania, is 1.55. In short, I consider it established beyond all doubt, that the Worcester coal belongs to an older formation, and is in fact almost converted into graphite. The two formations have no connection whatever; and are separated by a wide district of gneiss.

The Worcester anthracite forms a bed in a carbonaceous mica slate, approaching closely to argillaceous slate, running nearly N.W. and S.E. and having a moderate dip to the northeast. It has not been explored but a few feet in depth. Before the work was abandoned by its enterprizing proprietor, Colonel Binney of Boston, an attempt was made, by going down the hill on

which the bed is situated, and taking off the soil, to reach the lateral outcrop of the coal; which could probably have been easily accomplished, and would greatly facilitate the operations. I have been informed by Dr. Amos Binney of Boston, the present proprietor, that he intends resuming the work.

As might be expected from a coal so mineralized, the Worcester anthracite ignites with much more difficulty than that from Penesylvania, or Rhode Island. But gentlemen who have tried it, for warming their houses during the winter, among whom may be mentioned Mr. Thomas for many years the keeper of a hotel in Worcester, have assured me that it may be used comfortably and successfully for fuel. And in some manufacturing establishments it is preferred to most kinds of coal. Its analysis, however, indicates more earthy impurity than exists in most good coals. An ordinary specimen yielded as follows in 100 parts.

Water,	3	
Carbon,	77	
Earths and oxides,	20	
	100	Specific Gravity 2.12.

A second specimen, almost converted into plumbago, yielded as follows.

Water,	2.4
Earthy Residuum,	26.6
Carbon,	71.0
	100.0

According to the experiments of Mr. Bull of Philadelphia, a pound of the best Pennsylvania anthracite maintained ten degrees of heat in a room, 13 hours and 40 minutes, a pound of the Rhode Island anthracite maintained the same heat in the same room, 9 hours 30 minutes; and a pound of the Worcester anthracite, 7 hours 50 minutes. Theory and experience, therefore, concur in bringing us to the conclusion, that the Worcester coal is of an inferior quality. Yet in a country so wanting in coal as New England, a deposit of inferior coal is not to be regarded as useless. The time will probably come when it will be regarded as very valuable.

By looking at the Geological Map of the State, it will be seen that the rock formation which embraces the Worcester coal, extends to the mouth of the Merrimack river; and of course, coal may be found in other parts of the formation besides Worcester. In Bradford, where the general aspect of the country, the character of the soil and of the rocks, correspond almost exactly to the region around Worcester, an exploration is going on for coal by means of boring, which has been continued to the depth of nearly one hundred feet. I saw, however, no peculiar encouragement

at this place, more than at almost any other in the town. Should coal be found there, it will undoubtedly be of the same character as that in Worcester.

Anthracite of Bristol and Plymouth Counties and of Rhode Island.

In my Report of 1835, I stated that we might reasonably look for anthracite coal in any part of the graywacke formation exhibited on the Geological Map. This exists in several patches in the eastern part of the state: viz. a small deposit on Parker river in Newbury; a much larger one around Boston; and the principal one, in Bristol and Plymouth Counties; extending also into Rhode Island. The latter covers an area of nearly 400 square miles: and upon this I marked on the map one locality of coal in West Bridgwater, one in Middleborough, and one in Wrentham; as also in Cumberland and Portsmouth in Rhode Island. In the autumn of 1835, a bed was discovered in Mansfield, which has since been considerally explored, and with others in that place, has proved more important than any other, and excited sanguine expectations that the region may prove an extensive and valuable coal field. Coal had, indeed, been discovered in that place 25 years before: but it was not till 1835, that any systematic efforts were made to explore the beds. Three mining companies have since been formed: viz. "The Massachusetts Mining Company," "The Mansfield Mining Company," and the Mansfield Coal Company;" each of which has opened a pit at different places; and in spite of the stagnation of business and enterprise, and the general incredulity in respect to the existence of valuable coal, they have been so far successful as to satisfy any reasonable men acquainted with coal formations, that a great deal of that mineral may exist beneath the deep diluvial coat of that region. I shall describe the principal excavations made by these companies, with the results to the close of 1838: when the operations were suspended, with the hope of obtaining aid from the Government of the State, to resume them on a larger scale. I have been informed that in the commencement of their efforts, they derived much assistance from the suggestions and advice of Dr. C. T. Jackson, the Geological Surveyor of Maine and Rhode Island.

The Massachusetts Mining Company commenced their explorations in 1835, on the farm of Mr. Alfred Harden, where a shaft sunk only 25 feet, struck a bed of coal 5 feet wide, and another only 1 foot thick, separated from the first by 10 inches of rock. The shaft has since been carried to the depth of 64 feet; and from the bottom of it, in opposite directions and following the bed of coal, drifts have been extended 150 feet, and rail-ways laid for bringing the coal to the bottom of the pit, from whence it was, until recently, raised to the surface by a windlass and hand power; but steam power is now used, which greatly increases the daily amount of coal raised. About 1,500 tons had already been raised from this mine, when I visited it in October,

1838 ; and a drift had been carried from the bottom of the shaft, in a south-east direction, several feet across the rock strata, in search of new beds. Only one about a foot thick had been reached.

The explorations at this spot have been carried forward under the direction of Gen. Samuel Chandler, of Lexington, who seemed to me to have managed the whole concern with remarkably good judgment, and to have brought the principles of science to bear upon practice with singular success. In his printed Report to the Company, he says, that "although the region has been but very imperfectly explored, even where the strongest external evidence appears, yet four separate veins are known to occur on land leased to the Massachusetts Mining Company, situated at no great distance apart, and parallel in their line of bearing: two of which have been opened sufficiently to ascertain their thickness to be over five feet," &c.

The clerk of the company, William B. Dorr, Esq., makes the following statement in respect to these explorations, which must be regarded as very encouraging. "The Massachusetts Mining Company," says he, "at an expense of less than $15,000, with all the discouragements of a novel undertaking, the almost entire want of practical knowledge of the subject, and the cost of experiments which experience would have rendered unnecessary, have been able to raise from 1200 to 1500 tons of coal, worth from $5000 to $6000, at the lowest estimate both of the quantity mined and of its true value." "The directors have unhesitating confidence in the eventual success of the mining operations at Mansfield; and nothing but the universal prostration of enterprise and business, has prevented their pursuing these operations on a scale commensurate with their confidence and the public importance of the subject."

There are two methods of ascertaining the value of this coal for fuel: both of which it is desirable should be applied. One is chemical analysis: by which we learn how much carbon, or combustible matter, it contains, and how much earthy residuum that is useless: and the other is experience in using it. In 1835 Dr. C. T. Jackson analysed two specimens taken from the depth of about 25 feet, and the results were as follows:

1st. Specimen.		*2d. Specimen.*	
Carbon,	98	Carbon,	96
Peroxide of iron and alumina,	2	Peroxide of iron and alumina,	4
	100		100

I have made but two trials with specimens obtained at the mine in 1838, and the result is as follows:

1st. Specimen.		*2d. Specimen.*	
Carbon,	94	Water,	5.6
Residuum,	6	Carbon,	88.8
		Residuum,	5.6
	100		
Specific Gravity, 1.70.			100.

The amount of carbon in these specimens is a little greater than Prof. Vanuxem obtained from two specimens of anthracite from Rhode Island. In one he found an earthy residue of 5.07 per cent. and in the other of 15.60 per cent. He also found about the same per cent. of water as I obtained in the second trial; this item having been neglected by me in the first trial, as well as by Dr. Jackson, as our chief object was to ascertain the amount of earthy residuum. The amount of carbon in the Mansfield coal is nearly equal to that in "the purest anthracite of Lehigh," in which Prof. Vanuxem found 3.3 per cent. of earthy residue, and the mean of the

four analyses given above is only 4.4 per cent. of residuum. The composition, then, indicates the very best kind of anthracite. Its specific gravity, however, is 1.70; while a specimen of Peach Mountain coal in Pennsylvania, was only 1.49; and hence, perhaps, we might expect some more difficulty in producing perfect combustion in the former than in the latter.

As to the testimony which experience gives to the value of this coal, so far as that testimony is within my reach, it corresponds to what chemical analysis would indicate. It ought to be recollected, however, that beds of coal near the surface of the earth, are always more less affected by the action of water, which insinuates itself into their crevices. I have understood, that from this cause the coals of Pennsylvania have improved since the beds were first opened. It ought also to be recollected, that coal from a new locality may be expected to require a little different mode of management to make it burn well; and also that when men do not find such new article to conduct precisely like that which they have been accustomed to use, they are apt to infer at once that it must be of an inferior quality; and they are not willing to be at the trouble of making experiments to get over the difficulty.

"The quality of this coal," says Gen. Chandler, "has given very good satisfaction generally to the purchasers, notwithstanding it was taken by many under unfavorable circumstances."—"Many competent judges who have had opportunties of testing its qualities thoroughly, represent it equal, in their opinion, to the Pennsylvania Anthracite in all its essential properties."—"The fine coal has been taken in considerable quantities and used as fuel for steam power, and proves to be a very superior article for that purpose, &c."

Foster Bryant, Esq., of Mansfield, who appears to be very familarly acquainted with all the mining operations in that region, states, that as the beds have been explored to greater depth the quality of the coal has improved, which he imputes to the action of the water upon the upper portion of the beds. This often prevents the thorough combustion of the coal, although it ignites without difficulty and burns well for four or five hours. He adds, that "the coal of Mansfield, even in its present impure state, is capable of being converted to all economical purposes, and contaminated as it now is by adventitious substances, it is a better, far better article, than the coals from the Little Schuylkill were in 1831, and altogether better than the first year's produce from the Lackawana mines."

"The quality of the coal," says Mr. Dorr, "has afforded entire satisfaction to those who have taken the pains to give it a thorough trial, and to investigate its distinctive properties. Several of the directors use it exclusively for fuel, in open grates, cylinder stoves, and cooking ranges. It is found to ignite and burn best with a very moderate draught: and broken to about the size of a butternut. Uniformity in size is of course desirable. Under favorable circumstances, little difference is found in comparison with the best Pennsylvania anthracite, whether in relation to facility of ignition or intensity and durability of heat."

"The community generally, from feeling less interest in its success than the proprietors, will naturally take less pains in its use; and like every new discovery, its general introduction will doubtless be gradual."

In my Report of 1838, I adduced the testimony of Capt. Bunker and 35 passangers, of the steam boat President, on board of which the Mansfield coal was used during a trip from Providence to New York. They regarded this coal "fully equal to the Pennsylvania coal in all essential properties." In a Report on the Coal Mines of the state, made to the Legislature of Massachusetts in 1839, we have a similar certificate from 16 of the inhabitants of Mansfield who had used the coal in their stores and families. They state that "the coal taken from 26 to 50 feet in depth was poor, and much of it scarcely capable of combustion," but "that taken from the depth of 60 feet and upwards, is equal to the Pennsylvania coal in all respects excepting a larger portion of waste," (p. 34.) A short account which I shall give in the sequel, of the coal mines of Rhode Island, will tend to confirm this testimony still farther.

Explorations of the Mansfield Coal Company, and the Mansfield Mining Company.

The Mansfield Coal Company have simply sunk a shaft of 64 feet near the center of Mansfield, but have met with only a little coal: another shaft was sunk, half a mile north-west of the Harden farm, by the Mansfield Mining Company, to the depth of 84 feet, in which a bed only a few inches thick was crossed. A drift was then commenced at the bottom of this shaft, horizontally, towards the southeast so as to cross the strata. This had not been pushed far, when a bed of coal was struck, which, at the place, was about 10 feet thick; though on exploring it laterally for a few feet, it was found to be somewhat irregular; as indeed most of the beds are in the region, and as they are in fact in all coal fields. In crossing this vein, 25 tons of coal were thrown out, some of which is of a very superior quality; as may be seen in the collection (No. 207.) For specimens I am indebted to Mr. Joseph D. Clapp, the agent, who informs me that this vein has received the name of the "Wading Vein." When I visited it in October it had recently been discovered, and I have not since learned whether it has been pursued farther. I subjected 100 grains of it to analysis with the following result.

Carbon,	96
Alumina, Iron, &c.,	4
	100
Specific Gravity,	1.79

We have seen, from the testimony of Gen. Chandler, that four distinct beds of coal are already known upon land leased to the Massachusetts Mining Company. Mr. Foster Bryant states, that "seven distinct veins of coal have been struck in Mansfield, and the strongest indications are found of five more, one of which, from its great breadth is probably a continuation of the great vein at Cumberland." This is a great number to be discovered so early. For it ought to be stated that the whole of that region is covered by a coating of diluvial earth nearly 20 feet thick; so that it is only when in digging a well, or other excavation, that much chance exists for discovering the coal: for I could not learn that any streams in the vicinity have cut through this diluvium. The fact that with such peculiar difficulties in the way, so large a number of beds have been discovered in the space of a little more than two years, is to my mind a very strong proof that the region of Mansfield is likely to prove a very rich and valuable coal field. By looking at the Geological Map of the State it will be seen that the greywacke formation embraces a large part of Bristol and part of Plymouth counties, as well as a part of Rhode Island. All this space which Mr. Bryant estimates at more than 400 square miles, is to be regarded as a coal field; and indeed, on the northern side, which is nearly 30 miles long, coal has been found in various places through the whole distance. A very large part of this extensive region is covered by a thick coat of diluvium, as in Mansfield; and where rocks appear in place above the surface, they are those varieties of the greywacke which are least likely to contain coal, being coarse and hard. The coal usually occurs in fine dark colored slate, alternating with gray sandstone: and these are very liable to be disintegrated and worn away. Hence, the best prospect of finding coal is where the rock is most worn away, and the soil deepest. Such is the rock every where found in Mansfield, and since an almost perfectly level plain exists there, over many square miles, I infer that the rock is very similar over its whole extent; and hence that probably we may hope for more success in explorations there, than in almost any other part of the coal region above described.

It is a fortunate circumstance that the great Rail-Road from Boston to Providence passes across the center of the plain of Mansfield, and within 20 rods of the Harden farm, where the most extensive exploration has been made. From this spot it is 15 miles to Providence, 11 to Taunton, and 26 to Boston. A more favorable situation could hardly have been chosen for the location of this coal, had the proprietors themselves selected the site.

Coal rarely occurs in *veins*, properly so called: that is, occupying fissures *which run across the layers of the rock*. But it is uniformly found lying *between* the layers of the rock; that is,in what are called seams, or *beds*. If the layers of the rocks are horizontal, the beds will be horizontal. But generally, and especially in the graywacke formation, the strata dip more or less beneath the horizon, and of course the coal beds dip at the same angle. Being thus inclined, they will also run in the same direction as the upturned edges of the rock in which they are contained. Hence every coal bed will have a certain dip and direction. The extent to which the bed on the Harden farm in Mansfield has been opened, viz, 150 feet each way from the shaft, affords a good opportunity to determine these points in respect to that mine. I applied the clinometer and pocket compass at the bottom of this mine, and found the dip to be 53° north-westerly, and the direction nearly N. E. and S. W., though exhibiting minor deviations. And such are the dip and direction, within a few degrees, of all the rocks and coal beds that have been explored in the graywacke of Bristol County, and in Rhode Island; except that on the Island it is said the dip is nearly 90° south-easterly.

Now it is evident, that if a trench could be cut through the loose soil across the edges of the strata, it would bring into view all the beds of coal that exist in them. But several gentlemen who are practically acquainted with such operations, assure me, that such a trench would be far more expensive than it would be to sink a shaft several hundred feet into the rock; and then to push horizontal drifts through the rocks at right angles to the strata. And besides, were this done, and a rail-way laid at the bottom of the drift, as soon as a bed of coal was discovered, the mining and raising of it might immediately commence, without preventing the further prosecution of the drift.

This, then, appears to me, the thing that is wanted in the region under consideration. Suppose such a shaft, for instance, to be sunk 300 or 400 feet in the vicinity of the mine on the Harden farm, and a drift extended in opposite directions across the strata. We might be almost certain that these drifts would cross several valuable beds, since they are already known to exist in the vicinity. And thus the proprietors might have a fair prospect of remuneration, even if no new beds should be discovered: since this would probably, in the end, be the most economical way of opening the beds now known. But it is hardly to be conceived that no new and valuable beds would be discovered by extending the drift farther. Yet if they should not be found after carrying it forward a reasonable distance, it might be abandoned with little loss. How far it might be thought advisable to prosecute such a drift, it is difficult to say, until the work be begun: but perhaps it would be desirable to extend it several miles; which might be done, I understand, for less than $25,000 per mile, exclusive of the cost of the shaft. I should not be surprised if in tunneling towards the north-west, from the center of Mansfield, at the depth of 300 or 400 feet, the level should, ere many miles, be arrested by unstratified rocks, which rise to the surface within a few miles in that direction, and the graywacke may be thinner near the edges of the formation than in its more central parts. In the opposite direction, I should not expect any such obstruction, till the drift had been carried to the eastern part of Middleborough.

I have been told that the three companies above named, as engaged in mining for coal in Mansfield, have thought of uniting their resources for examining the vicinity of that place, by a plan essentially the same as that mentioned above. This resolution is certainly deserving of high commendation. For should these companies succeed in laying open a sufficient number of beds of coal to supply the wants of the eastern half of Massachusetts, (and I am not without strong

hopes that they may succeed,) so as to render our citizens independent of foreign importation, and reduce the price of fuel at least one half, hardly anything can be thought of that would give such a spur to industry and enterprise, and tend more to permanent prosperity. And allow me to inquire, whether the object is not of sufficient importance, and the prospect of success encouraging enough, to induce the Government of the State, by loan or otherwise, to encourage this undertaking. In general, it is probably best to leave such enterprises to private efforts; but in this case the investments must be so heavy that private companies may not feel justified in appropriating sufficient money to have the work done thoroughly: and if the Government, probably without any pecuniary loss, can lend its aid, it will give a powerful stimulus to private exertions. I make this suggestion, however, without any request on the part of these companies, and even with scarcely a personal acquaintance with any of their number.

It will probably surprise most of the citizens of Massachusetts to be informed, (as we are by the able report on our Coal Mines above referred to,) that about *two and a half millions of dollars* are annually sent out of the state for fuel! Not less surprising is the fact that Pennsylvania realizes from her coal mines an annual income of four and a half millions; and Great Britain, of 192 millions of dollars.

Diluvial Drift of Coal.

General Chandler mentioned to me a mode of exploring for coal, which he had successfully adopted, and which may be of use to others, depending on a knowledge of the direction which was taken by the diluvial waters that deposited the deep accumulation of sand and gravel lying over the coal region. It is an ingenious practical application, and at the same time a beautiful illustration and confirmation of the general doctrine advanced in my former Report, that a powerful diluvial current has swept over this state from the north. Whenever in digging into the soil he found fragments of coal, guided by this principle, he dug in a northerly direction; and never failed to find the number and size of the fragments to increase until he arrived at the bed from which they were broken. Following the fragments in the opposite direction, they continued to decrease in size and number until at the distance of several rods from the bed they disappeared. Hence, if in digging through the soil no fragments of coal should occur, it might pretty safely be inferred that no bed of much size exists for several rods in a northerly direction; and if they are found, the explorer need be at no loss in what direction he will find the bed.

Coal Bed in Foxborough.

I ought perhaps to have described the coal bed in Foxborough earlier. For it is only about two miles from the excavations in Mansfield, and belongs to the same coal field. Good coal was obtained there, formerly, in two places a few rods apart: but the shafts are now filled up. A specimen of this coal gave the following results upon analysis:

Water,	5
Carbon,	77
Earths, oxides, &c.,	18
	100

Specific gravity, 1.86.

The quantity of earthy matter here is much larger than in the specimens from Mansfield; yet it is not much larger than some of the coals contain that are extensively used; and very probably the specimen which I analyzed was comparatively poor. It is not probable, however, that this bed will be re-opened at present.

Anthracite in Wrentham.

Several excavations have been made in the southerly part of Wrentham for coal: but only in one place has any been found: although some interesting vegetable relics have been brought to light at nearly all the pits. At the place where some anthracite has been discovered, an exploration 180 feet deep has been made; all except 10 feet, in a dark carbonaceous slate, running nearly east and west, and dipping north about 45°. The specimens of coal were a good deal mixed with earthy impurities and iron pyrites. Nevertheless I analyzed one of them with the following results.

Water,	6.6
Carbon,	50.4
Earths, oxides &c.	43.0

Unless a purer variety than this can be found, it will hardly be worth exploration; and in fact the exploration has been abandoned; as beds, even of a variety so poor, have been yet found only a few inches thick.

Anthracite of Rhode Island.

I notice in this place the coal of Rhode Island, first, because it is found in the same coal formation which occupies the southern part of Massachusetts: secondly, because the beds lie so near to Massachusetts as to be as important to her inhabitants as to those of Rhode Island: and thirdly, because some of these beds have long been wrought and experiments were made to determine the value of the coal for fuel: and therefore will help us in forming an opinion respecting the coal of Massachusetts.

The coal bed in Cumberland, which is only a mile or two from the Massachusetts line, was discovered and opened somewhat earlier than those in Mansfield. The dip and direction of the beds are the same in both places. The bed in Cumberland was 9 feet thick at its outcrop, beneath 20 feet of diluvium: but at the depth of 40 feet, it had increased to 14 feet. It was explored 70 feet deep, or 300 feet laterally, when the work was suspended by the destruction of the machinery by fire. The testimony of Mr. John Alexander, the agent of the N. England Coal Mining Company, by whom the mine has been opened, and of several other gentleman who seem to have given the coal a fair trial, is very decided that this coal is of a good quality, not inferior to that in Mansfield, and scarcely inferior to that from Pennsylvania. It is also the uniform testimony, that it increases in value as the depth increases from which it was obtained. (*Report on the Coal Mines of Massachusetts p.* 29.) It is greatly to be desired, that the application of this Company to the Government of Rhode Island for aid in reopening this mine, may be successful.

In the south part of Newport, on the island of Rhode Island, beds of anthracite occur a few inches in thickness. During the revolutionary war, the British army, after consuming nearly all the wood upon the island, attempted to find coal at this place; and the marks of their explorations yet remain. But near the beginning of the present century, more extensive excavations were made at Portsmouth, in the north part of the island, and with no little success.

Dr. Meade says, that the vein then wrought was 14 feet wide; and 'with only fifteen work men, they can raise at present from 10 to 20 chaldrons of coal per day, besides keeping the mine free from water; from which they suffer little inconvenience.'* He speaks of the bed of coal as 'not horizontal or vertical, but forming an angle of about 75.°

* Bruce's Mineralogical Journal, January, 1820, p. 84.

A great variety of causes led to the abandonment of these explorations; but a few years since they were again resumed; and through the kindness of Dr. Thomas H. Webb, of Providence, I have before me a letter addressed to that gentleman, from J. Clowes, the intelligent agent employed to superintend this second exploration; from which I derive the following facts respecting the anthracite of Portsmouth. The letter is dated February 18th, 1828; which appears to have been about the time when the work was the second time abandoned.

The quantity of anthracite raised at these mines in 1827, by 20 men and 5 boys, was 2200 tons, and an equal quantity of *slack:* that is, very small coal and dust. The former sold at the mine for $4.50 per ton, of 2240 pounds; and the slack for $1 per ton. The slack was used for burning lime and bricks. The best coal was mostly employed for fires in families, except in New York, where it was used for making glass; for generating steam under the common circular or round boiler; for blacksmiths; and in general for any purpose where anthracites are employed.

The agent regards these mines as capable of furnishing an inexhaustible supply. He represents the coal as occurring in veins; but his descriptions apply rather to beds; and I am almost certain that it occurs in beds. Six of these have been expcsed; and more than 30 are said to exist in that part of Rhode Island. Their direction is southwest and northeast, and they dip southeast from 40° to 90.°

The following are the strata that were penetrated in sinking a *water shaft*, or *engine pit*, 87 feet; and in fifteen other places they were found to be very similar.

Sand and Gravel,	9 feet.
Dark Colored Slate,	12
Hard Compact Graywacke,	23
Soft Black Slate,	4
Hard Brown Slate,	5
Soft Fine Gray Slate,	1
Very Hard Brown Slate,	17
Gray Freestone,	12
Coal,	4

Vegetable remains were found only in one of these excavations, about nineteen feet below the surface.

The failure of the mining operations in Portsmouth, between the years 1809 and 1816, resulted, according to Mr. Clowes, from two general causes: 1. A want of practical skill in those who conducted the operations. This prevented as much system in the works as was necessary, and also the introduction of proper and economical machinery. And he says, that 'amongst the many losses, which contributed to work their ruin, that was not the least, of allowing or permitting the workmen to have from half a pint to a pint of spirituous liquors during the working hours. We neither allow nor permit any thing of the sort, nor is it allowed or permitted in any mining establishment in Europe. Instead of benefitting a man it actually incapacitates him: and exclusive of the immoral effects on the passions of the workmen, I consider it a loss to the owners of at least one sixth of the whole manual labor.'

The second cause of failure, he says, lay in sending the coal from the mines in an improper state; that is, unsorted, and in too large lumps. He says that the Rhode Island coal does not break easily when ignited, like the Lehigh coal, and that this fact and the amount of impurities which it contained, injured its reputation in the market. He thinks that if mixed in equal quantity with the Pennsylvania or bituminous coal, it answers best for fuel: and he says he has abundant evidence, that one ton of the Rhode Island coal, mixed with a ton of that from Pennsylvania, is equal to two tons of the anthracite from the latter state.

Formerly I confess I had not great confidence that its value or extent was great. But more thorough examination and the development of new facts, have produced a sincere and strong conviction that both Massachusetts and Rhode Island possess in this formation a treasure, as yet mostly hidden, but which will be more appreciated as it is more developed.

Bituminous Coal.

The sandstone formation in the valley of Connecticut River is the only region in Massachusetts where bituminous coal has been, or probably ever will be found. As yet it has been discovered there only in thin beds of little importance; and it becomes an interesting question whether the prospect of finding larger beds is great enough to justify an extensive exploration. The first point to be determined is, to what part of the series of rocks is this sandstone formation to be referred? From the fact of its containing coal some have referred it at once to the coal formation. But from arguments which I shall present in the scientific part of my Report, I am forced to the conclusion that it belongs rather to the new red sandstone series; or that it is the equivalent of that formation in Europe.

Yet if this be admitted, shall we infer that there is no hope that it may contain coal in such quantity, and of such quality as to be useful for fuel? A few years ago, geologists would have peremptorily decided this question in the affirmative: but in the present state of their science, it seems to me we may at least reasonably hesitate, and perhaps draw a contrary inference. It is now generally admitted that all coal has a vegetable origin; and that simply by the long continued action of water, under certain circumstances, vegetable matters pass into the state of peat, next into lignite, then into bituminous coal, and finally into anthracite: though this last substance more commonly, perhaps, results from the action of heat on bituminous coal: and if the heat be powerful enough, even plumbago may be produced: 'as wood has been, thus changed,' says Dr. Macculloch,* 'in my experiments, and as coal is daily in the iron furnaces.' Such a change he found, in one case at least, produced upon common coal, in the vicinity of a trap dyke: hence he reasonably infers, 'that even the plumbago of the primary strata, no less than the anthracite, might as well have originated in vegetables, as that each of these should owe an independent origin to elementary mineral carbon.'

According to this theory, why may we not hope to find large quantities of workable coal in any formation where we find it in small quantities? For, the same causes that could produce it in thin beds, might reasonably be supposed adequate to the production of large masses. Anthracite is found in almost every rock from lias to gneiss; and bituminous coal occurs in the oo-

* System of Geology, &c. Vol. 1. p. 298.

litic and new red sandstone series, as well as in the proper coal measures.* True, so far as we yet know, the coal measures contain the principal deposits of the latter species in Europe; and perhaps in this country: But who knows whether the circumstances under which our new red sandstone was deposited, might not have been such as to produce extensive masses of coal? This would not constitute so great a difference between our new red sandstone and most of that in Europe, as the almost entire absence in the former of gypsum and rock salt; minerals which, on the eastern continent, are regarded as eminently characteristic of this formation. In Yorkshire, England, coal has been found in the new red sandstone: and on the European continent, as in Poland,† occasionally in thin seams: and it has been recently ascertained, that the Brora coal field in Scotland, which is probably the equivalent of that of Tecklenberg—Lingen, in Prussia, is contained in the lias;‡ a formation which lies above the new red sandstone; and, therefore, every presumption is in favor of finding coal in the new red sandstone; since this lies between the lias and the real coal measures. This conclusion is still farther strengthened by the fact, that Humboldt, Daubuission, and other able geologists, consider the red sandstone group, and the coal measures, as belonging to the same formation.§ All these facts prove, it seems to me, that it was a hasty generalization which limited workable coal to the coal measures; and that, therefore, we should not be prevented from searching for coal in the new red sandstone of the Connecticut valley. And besides, it may be that the true coal formation lies beneath the red sandstone.

The coal in this rock occurs in the form of thin beds and irregular nodules, which are rarely but a few inches in diameter. In almost every instance, it appears to be the result of the carbonization of a single plant, whose form can be distinctly traced; though it is always broken into fragments, whose length rarely exceeds two feet. At Whitmore's ferry in Sunderland; in the north part of South Hadley, and on the north bank of Westfield river in West Springfield, the coal is highly bituminous: though least so at the last named locality. But at Turner's falls, in Gill; at the Southampton lead mine, and at Enfield falls, (Connecticut,) it is anthracite. At the junction of this same formation with the greenstone at Berlin, in Connecticut, Dr. Percival has described a vein of bituminous coal penetrating the greenstone. He says, however, that 'it more usually has the appearance of cinders so mixed up with siliceous matter as to be hardly combustible.'

It becomes an interesting inquiry, whether local circumstances will enable us to explain why

* See Brongniart's Tableau de la Succession et de la Disposition des Terrains et Roches, &c. Paris, 1829. Also Conybeare and Phillip's Geology of England and Wales, Vol. 1 p. 329. Al. Brongniart also describes, as occurring in the Plastic Clay Formation of Mount Meissner in Hesse, 'a true anthracite—that is to say, a dense carbon without bitumen, sometimes with a dull, sometimes with a shining fracture. We here find a thicker bed of compact, solid, bituminous carbon, having a nearly straight fracture, burning with facility, and presenting many of the characters of true Coal.' Phil. Mag. Vol. II. N. Series, p. 108.

† Conybeare's Report on Geology, (1832) p. 390.

‡ Philosophical Magazine, Vol. II. N. Series, p. 101.

§ De la Beche's Geological Manual, 2d. Edition, (London, 1832.) p. 405.

the coal at some of these localities is bituminous, and at others anthracite. 'We know,' says Prof. Al. Brongniart,* 'that the coal which is in contact with the veins or dykes of basanite, or trap, that traverse it, and that which approaches masses of porphyry, is less bituminous than other portions of the bed, and that it even loses all its bitumen, and in passing to the state of anthracite, exhibits, as it were, a kind of vitreous texture, &c.' Few geologists will now doubt but the proximity of granite produces a similar effect. Now at Turner's falls we know that a large mass of trap is not far from the coal; and at Southampton, that granite is still nearer; and hence we should expect the coal at these places to have lost its bitumen. I am not aware, however, of the proximity of either of these rocks to the coal at Enfield falls; though ignorant of its particular location. At Sunderland and South Hadley the trap is so far distant, that we are not surprised to find bitumen. The existence of bituminous coal, however, in the trap at Berlin, Ct. is quite remarkable; and the fact that a portion of it is converted into pseudo cinders, proves that heat does not necessarily drive out the bitumen. The contorted condition of the strata at the locality of coal in West Springfield, renders it quite probable that trap rock exists a short distance beneath the surface. The pretty uniform dip of the strata, where they are laid bare in that town several miles in width, by Westfield river, is from 15° to 20° east. But at the spot

A  E

just referred to, we find the anomaly which is here sketched. It is a satisfactory explanation of this case to suppose that greenstone, or some other igneous rock, has pressed upwards with such force between A and E, as to give to the strata a saddle shaped appearance for a few rods. (Four rods from A. to E.)

Bituminous Coal, West Springfield.

Within a few years past, the banks and the bed of the river at the place above sketched, which is called Midneag Falls, have been somewhat extensively excavated for building factories. The consequence was, the bringing of coal of the most beautiful variety, that I have ever seen; a specimen of which is in the State Collection. It appears to exist here in the form of small and irregular veins, the coal also being filled with numerous thin veins and crystalizations of calcareous spar. This is a most remarkable mode of occurrence, and very interesting in a scientific point of view: and perhaps, also, of consequence in a practical point of view: otherwise I should not here describe it. Coal is, indeed, described in geological books as sometimes occupying fissures in rocks, along with fragments of those rocks: but in this case the coal is broken by mechanical violence. Yet at West Springfield, it has evidently been filled into the fissures, just as the associated calcareous spar was, by a chemical agency. The latter may have been deposited from water: but I can conceive of no way in which the coal could have been formed, but by sublimation and consequent solidification, as the temperature was reduced.

* Tableau des Terrains &c. p. 283.

In short, my supposition is, that coal may exist beneath this spot, and that by the agency of trap rocks, a part of it was melted, the superincumbent sandstone forced up, and into its fissures the sublimated coal ascending, but not being able to escape, was reconsolidated into coal. I am aware of but one analogous fact having been noticed elsewhere,* and this makes me less confident in this hypothesis. Yet every fact respecting the situation of this coal corresponds to it, as does also its chemical composition. For if it were the result of sublimation, we might expect it to be free from those earthy and metallic matters, that I believe have always been found in coal upon analysis. And such it will be seen, is the fact with the West Springfield coal: or rather it is free from impurity as most crystals are. It is, indeed, difficult to separate mechanically from this coal all the thin layers of calcareous spar with which it abounds, and hence there will often be a small residuum after burning in a platinum bowl: but diluted cold nitric acid dissolved this almost entirely, with effervescence in three trials which I made; and hence I conclude it to be carbonate of lime, which ought not to be reckoned as an impurity, because existing only in the fissures of the coal, and subsequently introduced.

A pure specimen of this coal yielded, upon analysis, as follows:

Volatile matter, (water and bitumen,)	22.00
Carbon,	77.97
Earthy residuum,	0.03
	100.

The method which I adopted to ascertain the amount of volatile matter was simply to heat the triturated coal in a broad platinum bowl, nearly to redness, until all the bituminous odor had disappeared. This, I am aware, is not a very satisfactory mode of determining the amount of bitumen; but it is sufficient for my present purpose to show, that a large proportion of bitumen exists in this coal. And every one must see, that its composition is such as would make it one of the finest coals ever discovered, could it be found in sufficient quantity.

If the hypothesis above advanced be true, there would result as an inference, a probability, that, by boring into the sandstone in the bed of the river at the highest part of the arch, a bed of coal might be discovered. And since the span of that arch is so limited, it seems hardly possible, that the

* Richard E. Taylor Esq. has recently described a genuine vein of bituminous coal of considerable extent, near Havanna, in the island of Cuba. His analysis of this coal is as follows,

Volatile Matter, (gas &c.)	63.00
Carbon,	34.97
Ashes and cinder,	2.03
	100.00

Philosophical Magazine, 3d *series Vol.* 10, *p.* 160.

upheaving power can be situated more than 100 or 200 feet below the river: that is, the trap rock, the supposed disturbing cause, would probably be struck before that depth were reached; and since the coal, if it exist, must lie above the trap rock, this would be reached. Whether the probability of finding a bed of workable coal is strong enough to justify the expenditure of a few hundred dollars in such an exploration, others concerned can now judge as well as myself.

Useless Search for Coal.

When we consider the great economical value of coal, it is no wonder that it should be sought after with great avidity. But it is to be regretted that so many unreasonable expectations of finding this substance prevail in many parts of the State, where a slight knowledge of the geology would enable any one to decide with absolute certainty that no coal exists. It may be stated with a good deal of confidence, that the graywacke formation in the eastern part of the state, and the sandstone on Connecticut river, with the range of imperfect mica slate extending from the mouth of Merrimack river to the south part of Worcester county, are the only portions of the state where coal will ever be found; and even in respect to the last named rock, it would be unreasonable to expect in it coal of much economical value. It is possible, I grant, that some of the dark colored slates of Berkshire County may contain anthracite, allied to plumbago; but very probably all their carbonaceous matter will be found to consist of plumbago: and it would be extremely injudicious to make any expensive researches in that county for coal. Indeed, the same may be said in respect to every part of the state except the valley of the Connecticut and the graywacke region of the eastern part of the state. Yet in almost every part of the commonwealth, besides those just named, I have found respectable men so confident that coal exists in their vicinity, that every effort of mine to convince them to the contrary, seemed only to increase their confidence in their opinion. In some cases it is easy to see how a person unacquainted with rocks is deceived. In Dedham, for instance, I noticed that in digging wells, it was common to strike upon a disintegrating trap rock, which considerably resembles the bituminous shale that encloses coal; and I found that the proprietor of one of these wells, which was originally commenced only for getting water, had been carrying it deeper in search of coal: and he appeared to be perfectly confident of finding it, by pushing the excavation deeper; which he intended to do ere long; and it seemed to me that all my endeavors to convince him that his labor and money would be lost, only strengthened his opinion. And yet granite and trap

were the only rocks visible in that vicinity! Coal was to be found in rocks which have most assuredly been once in a melted state!

A tradition has long existed that the Indians were acquainted with a locality of coal near Monument mountain in Great Barrington: and a few years since, a descendant of these natives, from the western part of the country, was induced to return thither in order to point out the spot where this treasure was concealed. He professed, however, to take offence at something and departed without making the disclosure. I think that I have been more fortunate, and have discovered the spot, without either an Indian or a mineral rod. At the eastern foot of Monument mountain, in an open pasture, lie, one or two large fragments of rock, containing *schorl:* a mineral exactly resembling coal in appearance: but which is not only not coal, but a certain indication that the rock in which it occurs does not contain coal. For it is a crystalized mineral, found only in the older rocks, and never in the coal formation. Yet this is the substance, which being discovered a few years ago at the mouth of Kennebeck river, led to the announcement in the newspapers that a rich mine of coal had been found there: and I doubt not but it formed the foundation of the tradition respecting coal at Monument mountain. Surely I cannot conceive what other appearance there could have given rise to such a story. For the mountain itself is composed of granular quartz, and all the region around is as unlike a coal region as it well can be: nearly as much so as a region of trap and granite.

It ought to be remarked, however, that anxious as our citizens are to find coal within our borders, and confident as many of them are that it exists around them, scarcely no expense has been incurred in useless excavations. And it is sincerely hoped that enough of geological knowledge is now diffused through the community, to prevent any of those extravagant enterprises of this kind, which have proved ruinous and ridiculous in other parts of the United States.

A year or two since it was stated in the public papers, that a rich deposit of coal had been found in Montague nearly opposite the mouth of Deerfield river. Appearances are indeed as promising at that spot, as almost any where in the valley of the Connecticut, the rock being shale resembling that which accompanies coal. And some of it is glazed with carbonaceous matter: and this is in fact the supposed coal. But having subjected some of it in an open platinum vessel to the heat of a strong furnace for 2 1-2 hours, it lost only 6.7 per cent. leaving 93.3 per cent. of matter absolutely incombustible! It is by no means impossible that a good bed of coal may be found at this place: but the preceding statement shows that it has not yet been discovered.

Peat.

Taking the state as a whole, peat is but little used, either as fuel or manure; though most employed for the latter purpose. Yet for both purposes its use is rapidly increasing, especially in the eastern part of the state, where fuel is more expensive. In view of its importance, I have made some efforts to ascertain its probable amount in our swamps. But this is very difficult; both because our swamps, where it occurs, have been but slightly explored, and because much is called merely mud, that deserves the name of peat. Several gentlemen, however, to whom I addressed inquiries on this subject, in different towns, have ventured to give an opinion as to the thickness of the beds, and the number of acres of peat found there. The following statement embraces nearly 50 towns; though by no means all in which I know peat to exist. But my object at this time is to give data for forming an approximate estimate of the amount of this deposit in the state.

Besides the towns mentioned in the table, appended, I am sure of its existence in the following places: and I doubt not but I might add nearly every town in the State. It exists in Seekonk, Uxbridge, Co!.assett, Medfield, Walpole, Wrentham, Dovers, Framingham, Sudbury, Topsfield, Ipswich, Pittsfield, Leverett, Hadley, Sunderland, Shutesbury, Lancaster, Hopkinton, Medway, Stoughton, Boylston, Reading, Milton, Needham, Billerica, Bedford, Waltham, Watertown, Action, Danvers, Chelmsford, Hamilton, Tisbury, Chilmark, Yarmouth, Brewster, Orleans, Eastham, Wellfleet, Truro, Provincetown, Falmouth and Barnstable.

TOWNS.	Thickness of the Beds.	Acres covered by Peat Swamps.	Use.	Authority.
Andover,	1 to 8 feet.	More than 2000.	Fuel & manure.	Alonzo Gray.
Athol,	2 to 3 feet.	Swamp 2 miles long, 80 rods wide, (300.)	Scarcely used.	Alden Spooner.
Abington,	Abundant.			Thom. H. Perry.
Amesbury,	10 feet, sometimes.	100 acres at least.	Little used.	Patten Sargent.
Barnstable,	15 feet, sometimes.	200 acres.	For fuel only.	
Buckland,	1 swamp 30 ft. deep of mud.	50 acres swamp.		Silas Smith.
Bellingham,	3 to 8 feet.	" Probably 5 or 6 acres."		John Cook, 2d.
Bernardston,		30 to 40 acres, much peat.	Manure only.	H. W. Cushman.
Bridgewater,	Extensive beds.		Fuel & manure.	P. Leach.
Concord,	2 to 8 feet.	500 to 700 acres.	do do.	Cyrus Stow.
Carver,	8 to 10 feet of mud in swamps.	500 to 800 acres bog swamps.	Not used.	John Savary.
Chilmark,	Various.	Perhaps 100 acres.		
Dennis,	1 to 4 feet.	100 to 200 acres.	Fuel.	L. Nickerson.
Dighton,	Plenty.		Not much used.	
Duxbury,	2 to 20 feet more.	Abundant.	Fuel & manure.	G. Bradford.
Eastham,	2 feet to unk. depth.	do.		George Collins.
Falmouth,	10 to 15 feet.	20 to 30 acres.	Manure.	Wm. Parker.
Groton,	5 to 20 feet.	Hundreds of acres.	Manure chiefly.	J. Green
Hingham,	2 to 6 feet.	50 to 100 acres.		Henry Cushing.
Halifax,	2 to 10 feet.	100 to 200 acres.	Begin. to be used.	J P. Thompson.
Hanson,	1 to 10 feet.	1000 acres.	Fuel & manure.	F. P. Howland.
Hanover,	Rather abuundant.		Lately used.	A. G. Duncan.
Holden,	Not abundaut.		Manure only.	John Chaffin.
Kingston,	2 to 10 feet.	Many Swamps.	Manure.	Asaph Holmes.

TOWNS	Thickness of the Beds.	Acres covered by Peat Swamps.	Use.	Authority.
Lunenburg,	Inexhaustible.	100 acres.	Not used.	
Longmeadow,		Perhaps 10 acres.		
Ludlow,	12 to 15 feet.	50 acres.	Manure.	H. W B. Alden.
Lynnfield,	10 to 12 ft. sometimes.	100 to 200 acres.		William Perkins.
Methuen,	3 to 6 feet.	More than 50 acres.	Fuel.	Stephen Parker.
Millbury.	3 to 10 feet.	Extensive beds.	Fuel.	Asa H. Waters.
Natick.	3 to 6 feet.	500 acres tested, 300 to 400 more	do.	Chester Adams.
Oxford.	4 to 12 feet.	Several hundreds.		Stephen Davis.
Nantucket.	1 to 14 feet.	985 acres.		Jared Coffin.
Randolph,	1 foot to a great depth.		Fuel chiefly.	Zenas Frnch, Jr.
Rowley,	3 to 6 inches.	More than 500 acres.		
Roxbury,	30 inches average.		Manure chiefly.	A. A. Hayes.
Spencer,	2 to 30 inches.	1000 to 2000 acres.	Fuel.	Jonas Guilford.
Southborough,	Thick.	500 acres.	Fuel and manure.	Joel Burnet.
S. Reading,	3 feet average.	200 acres.		Lilley Eaton.
Weston,	10 feet and less.	Numerous Swamps.	Manure.	A. Bigelow, Jr.
Wales &Holl'd	4 to 10 feet.	200 acres.	do.	E. G. Fuller.
Wilmington,	" Two cuttings deep."	" Some hundreds."	Fuel.	Silas Brown.
Westford,	Abundant.			Julian Abbott.

It will be seen, that scarcely any towns, in the four western counties of the state, are mentioned above. This is partly explained by the fact, that fuel is more plenty there than in the eastern counties, so that public attention has never been directed so much to our fossil resources. But I think it undeniable, that the amount of good peat in the western counties is much less than in the eastern. Although perhaps the swamps abound as much in vegetable matter, that would be useful in agriculture, yet it does not seem to be converted into genuine peat, though I doubt not that it will be easy to find a large amount of it when there is a demand for it. Excluding these western counties, and taking the amount of peat given in the above statement as a fair average of its quantity in all the towns of the other counties, (excluding the large towns,) it would follow, that 80,000 acres, or 125 square miles, are covered with peat in that portion of the state, having an average thickness of 6 feet 4 inches. This area and depth would yield not far from 121 millions of cords. If this should be thought by any to exceed the quantity of good peat existing in that section, I presume no one will consider it too high an estimate of the amount of swamps filled with vegetable matter. I presume it falls far short of the true amount. And we hence get an enlarged view of the quantity of matter in the state that may be employed as fuel, or in agriculture, that has hitherto, except in some limited districts, remained almost untouched. It is true, that peat is not so convenient and agreeable a kind of fuel as good wood or coal; yet it certainly answers a very good purpose, and the facts in the case tend to allay the apprehension, which must sometimes rise in the mind of one who sees, in the gradual diminution of our forests, a future check to our prosperity and population. It is gratifying to learn, from so many towns, that the inhabitants are awaking so much to the

use of peat and peaty matter. Some gentlemen have even spoken of it as a "peat fever." I hope it has not yet reached its crisis.

VII. ROCKS AND MINERALS FOR ARCHITECTURAL AND ORNAMENTAL PURPOSES.

I bring under one head the two objects of architecture and ornament, because they are so intimately connected that it is not easy to separate them. Very little use, however, has yet been made of our mineral resources for mere ornament: but for the purposes of construction, they have been very extensively employed.

1. *Granite and Sienite.*

Much confusion has arisen in the application of these terms. They were originally applied to designate rocks very different, if not in composition, yet in their geological relations. But most of the rock that is generally described as sienite, is a variety of granite. This is certainly the case in Massachusetts. Wherever the granite admits hornblende into its composition, I have considered it as a sienite; and not unfrequently the hornblende constitutes the principal ingredient; taking the place, more or less, of the quartz and mica, so as to form a compound of hornblende and feldspar. This compound forms some of the most beautiful varieties of sienite, though extremely hard to work, for architectural purposes. But not a little granite that contains no hornblende goes by the name of sienite. Thus, much of the Quincy granite is wanting in hornblende; but being almost destitute of mica, and having the close aspect of sienite, it is called indifferently by either name.

The variety in the composition, color, and hardness of these rocks in Massachusetts, is almost endless. The quartz and feldspar are commonly white, yellowish and gray: the latter not unfrequently flesh colored: the mica is very often black, but sometimes of a silver color. When the quartz prevails, the rock is easily broken, but hornblende renders it tough. The predominance of feldspar generally gives the rock a more lively white color and renders it rather easier to work. But I shall not attempt to describe particularly all the varieties of these rocks that occur in the State. An inspection of the specimens which I have collected, will at once give an idea of the kinds obtained at the principle quarries, and of numerous other varieties which I have met with in different localities. (Nos. 1271 to 1348, and 1410 to 1458, also 2395 to 2477.)

The very coarse varieties of granite, which are found in some parts of the State, do by no means furnish a good building stone: indeed, some of them hardly serve for common walls. Much of granite in the vicinity of Connecticut river, is of this description; as also a considerable portion of that forming beds in gneiss, which extends from Southboro' to Andover. But most of the granite in the eastern part of the State, is of so fine a texture, as to answer admirably for architecture and other economical purposes. Along with sienite, it extends around Boston, running in a curvilinear direction, at the distance of fifteen or twenty miles. From Cohasset to Quincy, at the southern extremity of the curve, and from the end of Cape Ann to Salem, on the north, the formation is most fully developed, and is there quarried extensively. The Quincy quarries are probably the best and most generally known; and few citizens of the State are unacquainted with the rock thence obtained, now so extensively used in Boston and elsewhere. The quantities which those quarries (or rather mountains) will furnish, are incalculably great. One railroad, as is well known, has been used for several years to convey the granite from the quarry to Neponset river, a distance of three miles. It is thought, however, that the granite has not reached its *minimum* price. Yet even now, Boston is almost as much distinguished for its granite structures, as the metropolis of the Russian Empire.

Some of the granite obtained on the north of Boston, cannot be distinguished from that of Quincy. I observed the resemblance most strongly in Danvers and Lynnfield. At the former place it is quarried, and fine blocks are obtained. Extensive quarries are also opened in the north side of Cape Ann, in Gloucester, as well as at the Harbor. The rock here resembles that of Quincy; but it is generally harder and of a lighter color. At these quarries no railroad (except one of a few rods in length) is necessary to transport the rock to the sea-side: since vessels can approach very near the spot. And, since the demand for this rock must increase, in our country, for many years to come, and Cape Ann is little else than a vast block of it, it seems to me that it must be regarded as a substantial treasure to that part of the State,—far more valuable than a mine of the precious metals. At Squam, in Gloucester, I was informed that blocks of granite had sometimes been split out sixty feet in length; indeed, I saw the face of a ledge from which they had been detached. At Pigeons Cove a mass was detached 100 feet long and 4 feet thick.

At Fall River, in Troy, which lies upon Taunton river, are other extensive and interesting granite quarries. This granite, as the Map will show, is connected with the Quincy range above described. Yet the greater part of the granite in Plymouth and Bristol is coarser than that of Quincy and Gloucester, and more liable to decomposition. But no rock can be finer for

architectural purposes than the granite of Troy; and immense quantities have been obtained from this locality. The large manufactories at Fall River are built of it, as is also Fort Adams at Newport, Rhode Island. The feldspar of this rock is a mixture of the flesh red and light green varieties; the former predominating: the quartz is light gray, and the mica, usually black. It works easily, and has a lighter and more lively appearance than Quincy granite. Blocks of this granite have been split out from fifty to sixty feet long, as a sign-post at one of the former public houses at Fall River, will attest: it consists of a single block. The contiguity of this granite to water transportation, will always render it peculiarly valuable.

The granite range extending from Cohasset and Quincy, through Randolph, Stoughton, Foxborough, &c. nearly to Rhode Island, affords much valuable stone for architectural purposes: and it is wrought more or less in every town through which it passes.

The branch of this extensive deposit of granite, which is fully developed a little south-west of Dedham, furnishes some beautiful varieties of stone. No better example can be referred to, than the elegant pillars of the Court House in Dedham. This granite is very fine grained, and so white, that at a short distance it cannot be distinguished from white marble. The pillars just named were obtained near the dividing line between Dover and Medfield, where vast ledges of excellent stone occur.

The stone used in Boston under the name of Chelmsford granite, is found in a range of this rock, not connected with the deposit that has been described above. Nor does it come from Chelmsford; but from Westford and Tyngsborough. In the latter place, it is obtained chiefly from bowlder stones; but ledges are quarried in Westford. I do not know why it has been called Chemlsford granite, unless from the fact that large quantities are carried to Lowell, (formerly a part of Chelmsford,) to be wrought. This rock is pure granite, with no hornblende; and being homogeneous and compact in its texture, it furnishes an elegant stone. Good examples of it may be seen in the pillars of the United States Bank, and in the Market House in Boston. These were from Westford.

Four miles north of Lowell, a quarry of this granite has been opened in Pelham, N. H. Blocks may be obtained from this place of any length under thirty feet. It is a very fine variety, is much used, and appears superior to the Chelmsford granite.

The Westford and Pelham granite is connected with an imperfect kind of mica slate, in which it seems to form beds, or large protruding masses. At Fitchburg, a little south of the village, is a large hill of the same kind of granite. This is quarried though not extensively, on account of the little demand for the stone. This single hill 300 feet high, and nearly a mile in

circumference at its base, might furnish enough to supply the whole State for centuries. And there is needed only better means of transportation to bring it into extensive use.

The manner in which the granite is usually split out at the quarries is this. A number of holes of a quadrangular form, a little more than an inch wide, and two or three inches deep, are drilled into the rock, at intervals of a few inches, in the direction in which it is wished to separate the mass. Iron wedges, having cases of sheet iron, are then driven at the same time, and with equal force, into those cavities; and so prodigious is the power thus exerted, that masses of ten, twenty, thirty, and even fifty and sixty feet long, and sometimes half as many wide, are separated. These may be subdivided in any direction desired; and it is common to see masses thus split, till their sides are less than a foot wide, and their length from ten to twenty feet. In this state they are often employed as posts for fences.

Respecting the price of the granite from the quarries that have been described, I have not been able to obtain much information. At Fitchburg, I was told that it was sold at the quarries, well dressed, at forty cents the superficial foot; and at Squam at forty-five cents.

The cost of hammering and fine dressing granite in Boston, in the style of the Tremont House, I have been credibly informed, is about thirty cents the superficial foot. Ordinary work, however, is from twenty-five to thirty cents; and-not unfrequently, even as low as twenty cents.

Posts for store-fronts cost about thirty-four cents per foot in Boston. The columns of the Hospital were obtained for about one dollar per foot.

To show how rapidly the price of granite has fallen, I would state on the authority of a respectable architect in Boston, that the cost of the blocks of the Quincy granite for the Bunker Hill monument, delivered at Charlestown, in a rough state, was thirteen cents, three mills, per foot; and the cost of the unhewn stone for the church built in the year 1831, in Bowdoin street, Boston, was fifteen cents: but six years before, the rough Quincy granite, for the United States Branch Bank, cost two dollars per foot.

I have now given an account of the most extensive and important quarries of granite and sienite in the eastern part of the State. Granite is wrought more or less, however, not merely in all the towns through which its ranges pass, but also in other places, in their vicinity; large blocks of it having been removed thither by diluvial action in former times.

Although the granite in general, in the vicinity of Connecticut river, is too coarse for architectural uses; yet in Hampshire county are several beds of a superior quality. Perhaps the best is found in Williamsburgh, a few miles from Northampton. This rock, (some of which may be seen in the front of a few buildings in Northampton,) and in the mansion of the Hon. James

Fowler in Westfield, very much resembles the granite found in the vicinity of Dedham, and yields in beauty and value to none in the State. It exists in abundance in Northampton, Whately, and Williamsburgh; but nas yet been quarried only on a very limited scale.

On the east side of the Connecticut, a very beautiful sienitic granite exists in Belchertown; in which the mica, when the hornblende is wanting, is very black. It is not surpassed in elegance by any rock in the State; but it has not as yet, to my knowledge, been quarried at all. Indeed, very little real granite is employed in the middle or western parts of the State, except in a rough condition.

This sketch of the granite of Massachusetts, although brief, is sufficient to show that we have a great number of varieties, and an exhaustless quantity of this most valuable material for durable and elegant architecture. Numerous varieties not mentioned above, which have fallen under my consideration, either in ledges or loose blocks, will be found in the collection of specimens; and some of these are peculiarly beautiful. Numerous other varieties have doubtless escaped my observation. Indeed, we may safely assert, that no part of the world is better furnished with this useful and indestructible rock.

2. *Porphyry.*

This term, as it is employed in the arts, embraces several varieties of rock not designated by its strict geological sense. Although upon the Map, I have included in the term, only the porphyry of geologists, yet in this place, I shall describe all those compounds occurring among us, which have been denominated porphyry in the arts.

The first and most extensive of these, is the genuine feldspar porphyry, represented on the Map in large quantities in the towns of Medford, Malden, Chelsea and Lynn, on the north of Boston; and in Needham, Milton and Braintree, on the south. This is the oldest and most enduring of the porphyries, and, indeed, the hardest of rocks. Its basis is generally compact feldspar, reduced to a homogeneous paste, and of various colors; as light purple, red of various shades, brownish black, and greenish gray. The imbedded crystals are either feldspar, or quartz alone, or existing together in the same rock; and their colors are very various, though more usually white or gray. By these mixtures porphyries are produced, rivalling in beauty the best antique porphyry. This rock is polished with so great difficulty, that it is rarely used in our country, either for ornamental or useful purposes. But it would be strange if an increase of wealth and refinement should not create some demand for so elegant and enduring a rock. Whenever this shall happen, the vicinity of Boston will furnish every variety that can be desired, and in blocks large enough for any purpose. Quite a number of

smoothed or polished specimens may be seen in the collection. (Nos. 1231 to 1269.)

The porphyry range on the north of Boston, is most perfect in its characters, and in the greatest abundance at any one place; although the southern range spreads over a greater extent of surface. In Lynn, and some other towns, I have observed blocks of porphyry that were brecciated—that is, they were composed of angular fragments of porphyry reunited. This furnishes a beautiful variety for polishing, (Nos. 1264 to 1269.)

On many of the beaches south of Boston large quantities of porphyry, sienite, and granite pebbles, are accumulated, so that a fine collection may there be obtained. The places which I can refer to with most confidence, are the head of Nantasket Beach, the northeastern extremity of Cohasset, and the beach at the foot of Manomet hill in Plymouth. In a few places, as at Hingham, I noticed that these beautiful pebbles had been collected and used for paving the alleys in front of the houses: those of different colors being arranged in a beautiful manner so as to present an elegant Mosaic. It seems to me that if some of these pebbles were polished, or only varnished, so as to exhibit their true character, they might even be employed along with sea shells for parlor ornaments. At any rate, they would ornament a geological cabinet. And I have been surprised that no lapidary has made a collection of the many elegant varieties of our granites, porphyries, and other beautiful rocks, for the purpose of selling them. If they were only cut into small specimens and polished, and arranged into a sort of mosaic, set in marble, as is done so beautifnlly in Italy, can there be a doubt but they would meet with a ready sale? Even if no other varieties were introduced than I have placed in the Government collection, such a table must be an elegant parlor ornament, and the directions which I have given, will enable an artist early to find the localities of these. But many more varieties would no doubt be easily discovered.

The beach at Manomet hill in Plymouth, is almost entirely covered with bowlders and pebbles for one or two miles in length. I passed over its whole length one summer morning in 1839, so early that the sun had not dried off the rain of the preceding night: and the colors of the specimens were brought out as perfectly as by polishing. It was equal to passing through a fine geological cabinet. It was more: for this cabinet of nature was on so grand a scale as to throw into the shade all the works of man. Were I a resident of Plymouth, I am sure I should often anticipate the morning sun in an excursion to this spot.

Sienitic Porphyry.

When sienite contains crystals of feldspar imbedded in the mass, it is

said to be porphyritic; and some varieties of this rock in the eastern part of the State are very elegant. Essex county produces some of the finest specimens, particularly Cape Ann. Sometimes the imbedded crystals of feldspar, are white, sometimes flesh colored; and in Gloucester, I found a rock in which they were of a rich bronze color. These sienitic porphyries are extremely elegant when polished; but I am not aware that they are employed at all for ornamental purposes, in this country. (Nos. 1341 to 1346.)

Porphyritic Greenstone.

The ingredients of greenstone are often not easily distinguished from each other by the naked eye; and when, in such a case the rock contains disseminated crystals of feldspar, it becomes porphyritic. If these crystals are greenish white, and the base blackish green, the rock is the ***green porphyry*** of the ancients. In Dorchester, Brooklyn, and Roxbury, according to the Messrs. Danas, it occurs in rounded masses; and in small quantity, in veins, at Marblehead. But I have found it in large veins, traversing sienite at Sandy bay, on the northeast side of Cape Ann. Large blocks might be hence obtained: and if polished, it would constitute a truly splendid ornament for the interior of a church, or a private dwelling.

If the feldspar crystals be black, or grayish black, the rock is the superb ***black porphyry*** of the ancients. This occurs in small beds and rolled masses in Charlestown, and in veins of greenstone, at Marblehead, according to the Messrs. Danas: but I have not met with it.

The hornblende slate in various parts of the State, but particularly in the region of Connecticut river, is frequently porphyritic: and exceedingly resembles porphyritic greenstone; being, in fact, composed of the same ingredients; and differing only in its slaty structure, and in the more distinctly crystaline character of the hornblende. The disseminated crystals of feldspar are usually white: In Canton and Easton, they are sometimes the compact variety, yet retaining their form perfectly. A fine variety and in large quantity occurs in Heath, a specimen of which may be seen in the collection. (No. 944.)

In Ipswich I found a bowlder of greenstone in which are imbedded numerous distinct crystaline masses of jet black Karinthin. (No. 1159.) The same rock occurs in Durham N. H, and on the western slope of the Green Mountains in Vt. But I apprehend that the color of the rock is too dark to be employed much for ornament.

3. *Trap Rocks.*

All the trap rock of Massachusetts, that is of any importance in an architectural point of view, is greenstone.

so even, as to require but little dressing. Hence it is very common to see such large stones of this description in front of very many of our churches and other public buildings.

In Europe gneiss seems to have been applied to few useful purposes. A late geological writer in Great Britian, says that 'this schistose (slaty) body serves no particular purpose in the arts of life.'* Dr. Macculloch however mentions that the micaceous varieties are employed in building and sometimes for roofing.† This rock appears to be more perfectly developed in our own country than in Europe.

The western part of Worcester county, and the eastern parts of Hampden, Hampshire, and Franklin counties, afford the best quarries of gneiss. That branch of the Worcester range extending into Middlesex county, and the range in Berkshire county, do not furnish so good specimens for architecture, though by no means devoid of interest in this respect.

The quarries of gneiss that are most extensively wrought, and furnish the best stone, are situated in the following towns: Wilbraham, Pelham, Monson, Palmer, Montague, Dudley, Millbury, Westborough, Boylston, and Uxbridge. Much of the stone at these quarries can hardly be distinguished from granite, even by the Geologist. The Millbury gneiss, for instance, is very much used in Worcester, and does not there present any appearance of stratification, and very little of a slaty structure: while the granite, that is quarried in the east part of Worcester, is distinctly divided into parallel masses and would probably be called gneiss by most persons, rather than the Millbury rock.

At these gneiss quarries it is easy to obtain blocks from ten to twenty feet long, which are only a few inches thick. At Dudley, I was told that narrow slabs of this rock, such as would answer for posts or side walks, could be split out, and delivered in the center of the town for four cents per foot.

The quarries in Monson and Palmer are distinguished by one peculiarity of some importance. The strata are nearly perpendicular to the horizon, and are divided by a set of parallel seams, running horizontally, into blocks of any desired thickness, and of a width varying from one foot to four feet. This is most remarkably the case at a quarry 1 1-2 mile northwest of the center of Monson, where blocks may be got out 70 feet long. On dressing this rock the surface, from the irregularity of this laminar arrangement, and the diversified colors of the materials, becomes highly variegated, so as at a little distance to appear like clouded marble. This is a very frequent appearance in the gneiss of other localities; as in that of Millbury, Wilbraham, and Pelham; and often it is a really elegant rock. Good samples of this variegated gneiss may be seen in many of the houses and stores in Worcester, Springfield, Amherst, and: Monson: in the latter place especially in the dwelling house of Joel Norcross Esq.. Upon the whole the quarry in Monson above described, which is only two or three miles from the Springfield and Boston rail road, promises the most of any in the state Beautiful sepulchral monuments are some-

* Ure's Geology, p. 100. † Macculloch's System of Geology, Vol. 2. p. 155.

times made from it. For the sake of variety at least, one of this description ought to be placed at Mount Auburn.

5. *Hornblende Slate.*

This rock is usually associated with gneiss, and is by some regarded as a variety of that formation. Nevertheless it is a very different rock, both in composition and aspect. I do not recollect to have seen it employed in Massachusetts for any purpose except for common stone walls. It is often, however, very fissile, and presents an even surface. And in the side walks in the city of New Haven, I have noticed good flagging stones of this rock. I presume some of the localities in Massachusetts would furnish slabs for the same use: as for instance in the vicinity of New Bedford, and in the towns of Leyden, Heath, Warwick, &c.

6. *Mica Slate and Quartz Rock.*

The first of these rocks has usually a structure too irregular for the purposes of construction: But sometimes it can be split into large slabs of convenient thickness; as in the range that passes through Goshen, Chesterfield, &c. where it is quarried for hearths and door stones: it being so even and smooth as not to require dressing, and being also tolerably good for bearing moderate degrees of heat. The quarries of Bolton in Connecticut, which probably furnish the best flagging stones in the United States, are in mica slate, and the rock of Goshen, &c. might be used for the same purpose, were it near a market. But the principal use of the mica slate of Massachusetts is for firestone and whetstones: and these will be described in another place.

Our quartz rock, which is usually associated with mica slate, or gneiss, is less frequently employed than mica slate for the purposes of construction. From the quartz rock of Washington in Berkshire county, very fine flagging stones are obtained. In the narrow range also, colored as mica slate, but which frequently passes into quartz rock, running across the state from Monson to Warwick, I apprehend good flagging stone exists. I would refer particularly to a hill, 100 rods east of Sedgwick's tavern in the south part of Palmer, near the Boston and Springfield rail road. None of this has been dug out: but I am disposed to believe that this hill would furnish good stone for this purpose; and not unlikely also some firestone. I shall notice in another place other localities of quartz quartose firestone as well as quartz adapted for the manufacture of glass.

7. *Talcose Slate.*

The greater part of this rock, or those portions of it that usually go by the name of talcose and chlorite slate, are very similar to mica slate in their adaptedness for architectural purposes. But I hardly know of their being employed except for common walls. Soapstone, or Steatite, however, is now regarded as a variety of talcose rock; and this is one of the most valuable rocks in the state, and therefore its localities deserve special description.

I am of opinion that along the Western rail road, in the west part of Chester and Middlefield, good quarries of flagstone and of building rock may be opened in the perpendicular ledges of mica slate, talcose slate, and gneiss, which crowd upon and overhang that road. Other valuable rocks occur in the same region, as I shall soon show.

Steatite or Soapstone.

This is the softest of all the rocks employed in architecture. This property, rendering it easy to be sawed or cut without injuring an edge tool, and

its greasy or soapy feel, are such striking characteristics of this rock, that most people are acquainted with it. It is sometimes called *potstone*, and sometimes in this country, *freestone*. It is composed mostly of talc.

Next to the ease with which it may be wrought, its great power in resisting heat, is the most valuable property of this rock. Hence it is extensively employed for fire places and furnaces.

It is also turned into crucibles and small furnaces for culinary use. Inkstands are made of it in great numbers, and various other articles. As it hardens in the fire, it is used in Europe for imitating engraved gems. It has been employed in various countries as a substitute for soap and fuller's earth. Spanish and French chalk are varieties of steatite. Savage nations are said to mitigate hunger by eating this soft mineral; as however it contains nothing alimentary, it can act only as a palliative of hunger.* Those varieties that are most infusible are employed in England extensively in the manufacture of porcelain.

Steatite, like serpentine, usually occurs in beds of no great extent. They are numerous in Massachusetts, and very commonly they are associated with serpentine, or in the vicinity of it. This is the case in the northeast part of Middlefield, where one of the finest beds of it, in the State, is found: although it contains small masses of *bitter spar*, which renders it less easy to work. But this quarry has been explored more extensively than any other in the State; and the blocks transported to Northampton, and even to Boston. In Windsor are not less than three beds of this rock, from which the New Lebanon Shakers obtain it, for converting into inkstands. I found a small bed of it in Cheshire, one mile east of the Four Corners in the gneiss formation. Another occurs in Savoy; one in Hinsdale; one also in Blanford, which is wrought and produces an excellent stone. Two beds occur also in Granville. Another is opened in Zoar, where are two distinct varieties, one nearly white, another of a deep green. In Rowe is another quarry, where these two varieties are equally distinct. At the two last named localities, however, the rock is distinctly green and white talc; and indeed, the two minerals (talc and steatite) are probably in every case identical.

In the west part of Chester, near the Western rail road, and about a mile from where Henry's tavern was formerly kept, is a bed of considerable extent, between talcose and hornblende slate, and associated with serpentine. It has been wrought on a small scale, and may probably prove very valuable from its proximity to rail road. I am told that this same bed appears a mile or two farther north, on the east side of the river, towards Middlefield.

On the east side of Connecticut river are several beds of this rock, more or less quarried in every instance; but in general not explored deep enough to develope the rock in its unaltered character; for the air and moisture generally affect it for several feet deep. In the south part of

* See Brongniart's Mineralogy.

Shutesbury is one bed: in the southwest part of Wendell another; and two miles east of the center of New Salem, a third. In the west part of Petersham, a fourth. The quality of the rock at these places, is not as good as that west of the river; though it has scarcely been explored at all, at the localities above mentioned.

In Groton is a bed of soapstone on which considerable labor has been expended. Its width appears to be 10 or 12 feet, and it descends into the earth towards the southeast; dipping about 30°, and lying between layers of mica slate. It is of good quality, and its proximity to Boston, Newburyport, and Salem, will probably render it an object of importance.

A bed of soapstone has recently been discovered in Worcester; and the specimens thence obtained, (Nos. 403 and 1548,) show it to be more elegant in appearance than any other in the State. The bed has yet been penetrated only about five feet: but should it prove extensive, its situation so near the Blackstone Canal, will render it an object of no little importance. It is not now wrought.

In digging a well near the center of Millbury, a year or two since, a mass of soapstone of a rather peculiar character was penetrated: but it is not now accessible. In the same region, several years ago, in digging the Blackstone Canal, a variety was obtained, which, on being thrown upon hot coals, shot out into vermiform masses, which very much resembled living worms. It was for a time called vermiculite: but the name is very properly abandoned.

No. 2506 is a specimen of laminated green talc from Fitchburg. I am told that the bed is four feet thick, and most of it of a much finer grain than this specimen. A smaller specimen sent me is nearly compact. If enough of either kind can be obtained, free from foreign minerals, there is no doubt but it may prove valuable.

An interesting and important locality of this rock, is in the east part of Andover, four miles from the Theological Seminary. The bed lies in hornblendic gneiss, whose stratification is very irregular and indistinct; but I ascertained its direction to be almost N. E. and S. W. and its dip large, corresponding in both respects with the great deposit of gneiss extending diagonally across the state. The bed is not less than 50 feet thick; and has been opened by the proprietors, Flint, Jenkins & Co., several rods in length. They have wrought it for a variety of purposes, and it admits of being smoothed so as to appear well. Its composition is remarkably uniform, consisting essentially of rather hard foliated talc, though occasionally a black mineral is disseminated through it, which appears to be hornblende. Its strength appears to be greater than marble; as the proprietors informed me that a square piece 2 inches thick, laid on two supports 18 inches apart, sustained 800 pounds, laid upon a spot in the center only half an inch wide; 860 pounds broke it.

The specimen No. 2507 gives no idea of this rock, except as it is newly broken from the quarry. The proprietors, however, inform me, that one or two monuments made from it, have been placed at Mount Auburn. And for such a purpose it seems well adapted. I cannot but believe that this rock, which is certainly a peculiar one, and quite different from ordinary soapstones, will ere long come into extensive use, and the enterprizing proprietors be rewarded for their expense and perseverance. It seems applicable to nearly every use for which marble is employed.

Large bowlders of this rock are scattered over a considerable space around the quarry, in an east and west direction, , and since the diluvial current in this region was from the north, these bowlders render it probable that the bed is far more extensive than the spot which is opened; or that other beds occur beneath the surface.

In the southern parts of New Hampshire and Vermont, as at Francestown in the former, and at Windham and Grafton in the latter, are fine beds of this rock: and I am told that at present the shops in Boston are generally supplied from those places. But as better means of transportation are opened with the interior of the state, it is hoped that some of the extensive beds existing in our mountains will be explored. It is a substance that must always be in demand; and al-

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though capitalists may not expect very large returns from such investments, they can hardly fail of being safe, if the beds be carefully explored before they are opened.

8. *Serpentine.*

In New England serpentine is almost universally associated with steatite, either in talcose slate or gneissoid rock. And although generally regarded in Europe as an unstratified rock, in this country it belongs rather to the metamorphic class. But these points belong to the scientific rather than to the economical part of my report.

In richness and variety of colors, serpentine exceeds all other rocks; and is, therefore, eminently suited for ornamental sculpture and architecture. The prevailing color is green, of different shades, spotted or clouded, or veined with other colors; and hence its name, from its spotted and striped appearance, bearing a resemblance to the skins of some serpents. In hardness it varies very much; being in some instances very hard, and in others, as easily wrought as marble.

This rock exists in Massachusetts in great abundance, particularly in the Alpine part of the State, or in the Hoosac mountain range. The most extensive bed occurs in Middlefield, in the southern part of the town. This bed cannot be less than a quarter of a mile in breadth, and five or six miles long. The colors of the rock are various, and its hardness unequal. If wrought it might supply the whole world. It yields both the precious and the common varieties. There is another bed in the same town, associated with steatite or soapstone. In the west part of Westfield is found another extensive bed of this rock, extending into Russell, of a much darker color, and containing green talc. This has been used in a few instances for ornamental architecture, and has a rich appearance when wrought. Three beds of serpentine are found in Blanford, and another in Pelham, in the southwest part of the town. The color of this last is quite dark, and the quantity of the talc is considerably large. A large bed occurs in connection with soapstone, on the north side of Deerfield river, in Zoar, near the turnpike from Greenfield to Williamstown. Specimens from this place resemble those from the celebrated localities of this rock at Zobilitz in Saxony. Serpentine also exists at Windsor in two beds; and there is an immense bed of it in Marlborough, Vermont, and another still larger in Cavendish; as also in several other towns in the southern part of that State.

I do not doubt but many more beds of serpentine may be found in the broad mountainous range lying west of Connecticut river: for this rock is by no means apt to arrest the attention, and has indeed a forbidding and desolate aspect where it has been exposed to atmospheric agencies. In some of my most recent excursions to that region, I have discovered two new beds, not mentioned above. One is in the gneiss formation that shows itself a mile or two east of Cheshire four corners. A large amount of serpentine evidently exists here: but the extent of the bed is concealed by the diluvial detritus. The other bed is in the west part of Chester, associated with steatite, on the high mountain west of Westfield river. These two rocks lie between hornblende slate on the west, and talcose slate on the east, and extend southerly at least into the lofty mountain south of the southwest branch of Westfield river, and probably in a northerly direction quite as far. But as the serpentine is an object of no interest to any but the geologist, its extent has never been traced out. I have every reason to think, however, that both the steatite and the serpentine are associated, perhaps as a continuous bed, with the talcose slate nearly across the whole of Massachusetts.

A locality of noble or precious serpentine has long been known to exist in Newbury, two and a half miles south of Newburyport, at an abandoned lime quarry, called the Devil's Den. Only small masses can be here obtained: but when polished, they will compare with any in the world for beauty. (Nos. 870 to 873.)

When limestone is mixed with serpentine they constitute the famous *verd antique marble*; of

which such extensive beds occur near New Haven in Connecticut. Some of the specimens at Newbury are of this description; and more beautiful than that in Connecticut. Specimens are also common in the serpentine of Westfield; and in the west part of Middlefield. I have lately found a very delicate variety in the most easterly bed of limestone in that town. The limestone is hard and compact, of a white color, and the serpentine is of a delicate green, forming however but a small part of the mass. When polished it presents an agreeable aspect. (Nos. 1954. 1955.) It is doubtful whether large blocks could there be obtained. But both there and at Newbury pieces might be got out that would answer for small ornamental articles of great elegance.

A remarkably interesting bed of serpentine has been recently discovered in the town of Lynnfield, near the center of the place, where a quarry has been opened. The proprietor, Mr. James C. Nichols, informs me that he has traced the bed in a north-east direction from this spot two or three miles. Where it crosses the county road leading from North Reading to Salem, about a mile and a half from the quarry, a large quantity was blasted out, which was too hard to be wrought without great difficulty. The bed has not been traced far to the south-east of the quarry, as the rocks are mostly concealed by diluvium. But the great quantity of serpentine blocks scattered in a rather south-west direction for two or three miles, show that it does extend that way a considerable distance: while their great number gives us a striking idea of the extent of the whole bed. There can be no such thing as exhausting it. Its width in some places is not less than nine or ten rods.

From the direction of this bed of serpentine, as well as the character of the diluvium, I am satisfied that it is embraced in the great gneiss formation whose strata run from north-east to south-west across the state. Probably the bed is not far from the eastern limits of this formation.

When first quarried, " this serpentine is much softer," says the proprietor, " than any marble I have seen. It can be cut with a handsaw, or turned in a lathe, nearly as easy as *lignum vitæ;* but while in this soft state it will not receive so high a polish." The specimen No. 2182, which was polished and presented to the state collection by Mr. Nichols, will give an idea of common specimens of this stone. He says that " this serpentine can doubtless be wrought with less expense than common marble. We have made but a small opening, yet we have obtained some sound slabs five feet in length: and we shall doubtless find the stone sufficiently sound to afford slabs large enough for any ordinary purpose. We have not manufactured much of the stone, nor offered any for sale: yet we have full confidence that it would find a ready market."

Should it prove that this serpentine could be afforded at a cheaper rate than marble, I cannot see why it must not come into extensive use in all cases where a stone of a dark shade is preferred; though there will doubtless be found on exploration, pieces of various shades. The situation of the quarry so near the sea-board, and in proximity with several of the largest towns of New England, is an additional reason why I look upon this discovery as one of much promise.

Considering the extent and variety of serpentine in Massachusetts, it seems not a little surprising that no efforts, or next to none, have been made to use it for ornamental or architectural purposes. In Europe, it is employed for trinkets, vases, boxes, chimney pieces, and even columns of large size. In Spain, it is said that churches and palaces abound with columns of this description. If ever the serpentine of Massachusetts shall be extensively wrought, I doubt not that specimens will be obtained, rivaling the finest varieties of Europe. It is not at present easy to obtain hand specimens, that shall give a fair representation of this rock, because it is injured to a considerable depth, from the surface by exposure.

The composition of serpentine is regarded as an object of some economical importance, because valuable salts may be manufactured from it. I have therefore subjected a few of our serpentines to analysis; and the results are given in the following table.

No.	LOCALITY.	Magnesia.	Silica.	Peroxide of Iron	Water.	Loss.
870	Newbury, precious.	42.18	38.65	2.81	15.46	0.90
874	Chester, common.	44.91	34.91	10.27	9.45	0.46
879	Blanford, do.	40.19	38.09	6.75	14.77	0.20
893	Westfield, do. black.	33.74	43.03	8.88	13.93	0.42
2182	Lynnfield, do.*	42.00	37.00	2.00	15.00	4.00

The magnesia is the ingredient in serpentine that may be, perhaps, made of some economical value: and this seems, according to the above analysis, to be present in large quantity: By means of sulphuric acid this may be converted into sulphate of magnesia, or Epsom salts; and these by means of a carbonated alkali, may be changed into carbonate of magnesia; one of the forms in which this substance is sold in the shops. Whether such a manufacture would be profitable, I am unable to say. But I am sure that if such a process should be undertaken, Massachusetts can furnish enough of the material for all future generations and the whole world.

By comparing the present with my preceding reports, it will be seen that since the first one was published, I have discovered many beds of steatite and serpentine: And yet I have taken no special pains to find them: but have fallen upon them as it were accidentally; while pursuing the general objects of the survey. The announcement of deposits of such rocks, hitherto unknown, will not I am aware excite any interest in the community. Yet I cannot but regard every such discovery as adding a valuable item to our mineral wealth: for substances of this kind must come gradually into use as a country grows older and more wealthy: and when once brought into the market, the demand for them will never cease. Posterity, therefore, may be benefited by the new facts which I here present, if the present generation are not.

9. *Limestone.*

All rocks must yield in economical value to limestone. Its importance in agriculture I have already considered. But as a common building stone, as marble, and as forming the basis of several kinds of mortar, it still remains to be described.

Wherever limestone is abundant enough to be employed for making walls,

* Analysis by Dr. Charles T. Jackson.

it is one of the cheapest and best of all rocks. It is more easily wrought into proper shape, because softer, is less likely to be too fissile, and its appearance is better than most other stones. Hence it is sometimes employed in its undressed state for the walls of dwelling houses and factories: as at North Adams.

When, however, limestone is free enough from fissures and compact enough to admit of a good polish, so as to be employed as marble, it becomes still more valuable. A large proportion of the limestone in Berkshire county is of this description: but scarcely any attempt has been made to obtain marble from any other limestone bed in the state. It was formerly hoped that the bed in Stoneham would furnish even the rare variety used in statuary. And indeed, in small specimens it will compare advantageously with the famous Carara marble, so extensively employed for statuary: But it is said that it is so full of fissures that blocks large enough for that use cannot be obtained. Whether the bed has been explored far enough to settle this point, I am not prepared to say.

The best of the Berkshire marbles are white; most of them of snowy whiteness. Some of them, however, are clouded; and very frequently they are gray. The gray and the white are the most esteemed for durability. And it is this property that gives to these marbles, for the most part, their greatest value; although they admit of a fine polish, and for primary marbles, are very elegant.

In regard to the chemical constitution of these marbles, I find from numerous analyses, which I have made, that although magnesian limestones are very common in Berkshire, the best marbles are almost wholly free from magnesia. The beautiful clouded marble of Great Barrington is an exception; containing 38 per cent. of magnesia: and I have seen a few specimens of very fine white dolomite, that admitted of a beautiful polish: and in fact, formed as elegant a marble as I ever saw. (No. 1925.) But in general I do not doubt but magnesia is unfriendly to the firmness and durability of marble; as indeed chemical principles would lead us to expect. But more of this in another place.

The great and increasing demand for the marbles of Berkshire out of the state, and their high character abroad, render it proper to notice all the most important quarries that have yet been opened, and to give all the information which I am able to communicate respecting them.

To begin in the north part of the county, we find in North Adams a marble quarry of snowy whiteness; and as appears from the analysis that has been given, of great purity. It is indeed a pure highly crystalline carbonate of lime; free from magnesia, and almost free from iron. Large blocks of it are easily got out. At present, however, it is not so favorably situated in respect to an extensive market as the more southern parts of the county; and much of it is so highly crystalline as to mar its beauty; and probably also its strength: Yet it is a most valuable rock.

In New Ashford are several quarries of excellent marble, of a less highly crystaline character and a finer grain than that in Adams. The excavations have been made chiefly near the center of the town; and formerly a good deal of stone was sawed. But the business is not now carried on very extensively; not on account of any deficiency of materials, or defects in the stone, but because the quarries in the more southern parts of the county are nearer to good markets.

The western parts of Lanesborough furnish admirable facilities for the marble business. And the quarries there are very extensive. The stone is very much like that in New Ashford; being in fact a continuation of the same beds, which in Lanesborough are more fully developed and expanded. The analysis of three specimens of the best white and gray marble, as given in the general table, shows that they are very pure carbonates; scarcely exceeded by any others. A specimen of this marble may be seen in the Capitol at Albany; which is constructed of it. Greater facilities of transportation would undoubtedly much increase the demand for this marble.

In proceeding southerly, the next large quarry of marble is in the west part of Pittsfield, where inexhaustible quantities and of a good quality may be obtained.

To the south of Pittsfield the limestone formation is divided by a mountain range of mica slate. The westerly branch contains most of the stone best fitted for marble. West Stockbridge has long been celebrated for the great quantity and excellent quality which it produces: and from the table of analysis, it may be seen that the best varieties from that place vie in purity with any in the county. The small quantity of magnesia which they contain, does not probably affect their value at all: and the amount of iron, an ingredient which in my estimation is more likely than any other almost to injure marble, is scarcely worth mentioning. The marble of North Adams is perhaps a little nearer to absolute purity as a carbonate of lime, than that of West Stockbridge: but then the latter is more compact and firmer; qualities of high importance in good marbles: and often the translucency on the edge is as great as in good statuary marble. The quarries are numerous in this town, in almost every part of it. Most of the marble used in building the city Hall in New York, was from Fitch's quarry in the south part of the town. But at some of the other quarries, the stone appeared to me to be of rather a more delicate quality. A part of that in the State House in Boston is from the same town. It is fortunate that such immense quantities of so fine marble should occur at the intersection of two great rail roads: one of which, that to Hudson, is already opened to the west and will be soon easterly to Springfield and Boston: and in a few years to Albany.

The same range of limestone extends through Alford, Egremont, and Sheffield; and in several places in all these towns quarries are opened; and the quality is good. In the north part of Sheffield, is the quarry from which the marble is obtained for most of the columns of the Girard College in Philadelphia. This quarry is two miles north of the village. The strata, which are very thick, have an easterly dip of 60 or 70°. Blocks 50 feet long are sometimes blasted out by filling the crevices with gun powder; and masses of immense size are carried on carts constructed for the purpose, with large wheels, over the Taconic range, to the Hudson: where they are shipped for Philadelphia. Analysis shows this to be a quite pure carbonate; and yet I do not think it as delicate a stone as some other varieties in the county. The situation of the quarry however, is very favorable for exploration.

A mile or two west of the village of Great Barrington, is a quarry of the most beautiful clouded marble in the State: as may be seen by the specimens (Nos. 439.440.441.1932.) in the State collection. By analysis it appears that this rock contains nearly 40 per cent. of magnesia. This probably renders the stone more liable to break; still it is a substantial and certainly a beautiful marble, well adapted for mantle pieces and jambs. I find also that it is flexible: and since the flexible marble of New Ashford contains 16 per cent. of magnesia, I suspect this substance has

an agency in imparting this singular property; and I doubt not that numerous localities of flexible limestone may be found in Berkshire county.

In the year 1824 Professor Dewey estimated the value of the marble dug in Berkshire at $40.000. Charles B. Boynton, Esq. who has the principal direction of the marble business in West Stockbridge, has been obliging enough to ascertain the quantity dug in 1839: and he estimates it at $200.000. This rapid increase shows the high estimation in which the Berkshire marbles are held abroad. Until 1838 there existed no increased facilities for its transportation: and now a single rail road from the Hudson to the western limits of the county, is the only means of transportation not previously enjoyed. But soon this rail road will be completed to Boston, and the Housatonic rail road will connect the county with Long Island Sound. I regard therefore, an estimate of Mr. Boynton as very moderate, when he says; that "if general prosperity continues five years, Berkshire will at that time export marble to the value of half a million." He adds that "the demand for this article is constantly ahead of our means of supply: and this fact is now beginning to be understood abroad, and capital seeks investment among our hills and water powers." When we add to this statement, the great increase that will doubtless take place in the manufacture and export of quicklime, it will give some idea of the great value of the limestone deposits of Berkshire: of which its inhabitants generally seem to me to be little conscious.

O Fortunatos nimium sua si bona norint!

Mr. Boynton invented several years ago, and has long had in successful operation, an ingenious machine for planing marble. It would be gratifying, were this the proper place, and had I room, to give a description of this instrument. But no one can see it in operation without being satisfied that it must produce a very great saving of time and labor. It not only cuts all plane surfaces so smooth that for ordinary purposes they require no polishing, but also all strait mouldings and grooves with great facility and exactness.

I have a few suggestions to make respecting the means of determining the comparative durability of marbles from different localities: but as they will some of them apply to other rocks, I shall reserve them till I have completed the list of our rocks useful for architectural purposes.

Use of Limestone for Mortars.

The most important use to which limestone is applied is undoubtedly in the preparation of various kinds of mortar. For while marble must be employed only by the most wealthy, there is scarcely an individual in the community that does not sometimes use lime mortar: and none could be comfortable without it. I hope, therefore, that any suggestions which I may make, whose object shall be to reduce the price or improve the quality of the quicklime generally burnt in Massachusetts, will be received with candor.

The burning of lime and its conversion into mortar, have within a few years received much attention: especially in France, by Vicat, John, and Berthier; who have arrived at some important practical results. And as these are not generally accessible in this country, I shall briefly state them, so far as the present state of knowledge in Massachusetts on the subject seems to demand.

Calcination or Burning of Lime.

The burning of lime, so as to expel the carbonic acid, is the essential prerequisite in the formation of mortar: and it is accomplished in three modes: 1. Without a kiln: 2. By an intermittent kiln: and 3. By a kiln in constant operation; or as it is sometimes called, a *perpetual kiln.* The fuel employed is peat, coal, anthracite, or wood.

1. *Without a Kiln.* In Wales and Belgium the limestone is sometimes piled up in large conical heaps, the fragments being left much larger than when burnt in a kiln, and mixed with wood sufficient to burn it. The pile is then covered with turf exactly like a coal pit, and the process of burning is conducted exactly like that of a coal pit. In Belgium, a pile 16 feet diameter at the base, and 12 feet at the summit, occupies in burning six or seven days; and strange as it may seem, the lime thus produced is constantly preferred, at the same price, to that burnt in a kiln. I am not aware that limestone is ever burnt in this manner in this country: and yet I do not see but it might in some cases be a very desirable mode, especially where fuel is plenty and time and means are not at hand for building a kiln.

2. *Intermittent Kiln.* This is the most usual mode of burning limestone in this country. The kiln consists usually of a square or circular chimney, sometimes large and high enough to hold 900 bushels, but usually smaller, constructed at least on the inside, of stones that will bear a strong heat. In this chimney the limestone is piled up so as to leave an arched cavity underneath, as a place for the fire; which is usually continued several days before the calcination is completed. The fire is then allowed to go down, and the whole contents of the kiln are withdrawn to make room for a new charge.

It is obvious that by this mode of burning limestone, there is an immense loss of heat, as well as of time, in consequence of allowing the kiln to cool between each charge. Some saving of fuel may be made by constructing the kiln in the form of a cask, or egg, with the extremities cut off. A far more effectual remedy is to substitute the perpetual kiln, which will now be described. Where it is wished, however, to burn only a few hundred bushels of lime in a year, the common kiln may be cheapest.

3. *Perpetual Kiln.* This kiln is so constructed that the portion of lime which has become thoroughly burnt, can be removed without discontinuing the fire. And thus by removing the burnt lime from the bottom, and filling in at the top with fresh limestone, the process may be continued until the furnace needs repairs; which, in Belgium, is attended to once a year.

Fig. 1. exhibits the elevation, fig. 2. a vertical section, and fig. 3. a ground plan, of one of the most approved perpetual kilns, as it is constructed in Prussia; in which one part of wood and four parts of peat are employed. *d, d, d, d, d,* are five openings at the bottom, for withdrawing the lime as it is burnt: *c, c, c, c, c,* fire furnaces for the fuel, whose mode of connection with the cavity where the limestone is placed, may be seen at *c,* in the vertical section: which also shows at *d,* the manner in which the lime may be withdrawn. At *a, a,* is shown a lining of fire brick; back of which, is a cavity, *b, b,* filled with cinders, which act as a non-conductor of heat. The outside is built of rough stone. Its size can be learnt from the scale of English feet attached to fig. 2. It produces about 250 bushels of lime daily. *See Dumas' Chimie applique aux Arts, &c. Tome Deuxieme, p.* 489.

Fig. 1.

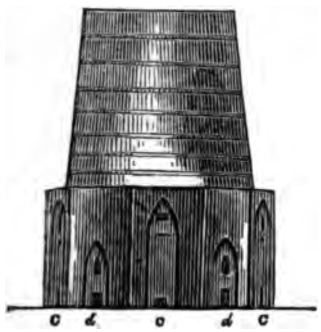


Fig. 2.

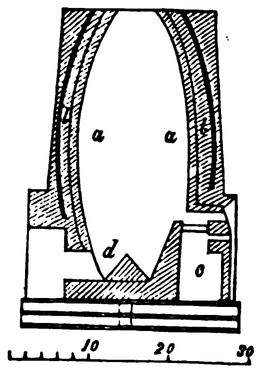


Fig. 3.

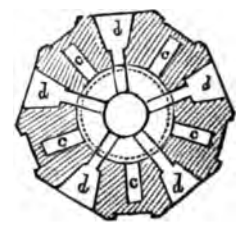


Fig. 4. is a vertical section of a plain perpetual kiln, which I visited in the north part of Richmond, Berkshire county. It is 25 feet high, and built of alternate layers of fire brick and stone. It is four sided; consisting of a single strait chimney, 4 feet square on the inside, and 8 feet on the outside; making the walls 2 feet thick. To the height of 7 feet from the bottom, it is 12 feet in one direction, for the purpose of making room for the furnaces, *d*, *d*, in which wood only is burnt, and which are 2 feet high, and 20 inches wide. For the passage of the heat into the limestone in the chimney, the bricks are laid up like a grate, as shown in Fig. 5. But it is obvious that an iron grate must be much better; and probably in the end more economical. *a*, *a*, are ash pits beneath the fires: *b* an opening for drawing out the lime from the bottom of the chimney, which is built towards its bottom exactly like the hopper to a grist mill; the opening at the bottom being about 18 inches square. This kiln consumes from 2 to 2 1-2 cords of wood daily, and produces 75 bushels of lime, which is drawn out at intervals of 8 hours. I do not suppose that this kiln is built in the very best manner: yet having been in successful operation for seven years, and being an easy one to construct, I thought a section of it might be desirable. The great quantity of wood consumed in proportion to the daily produce of this kiln, shows that there must be some defect in its construction. The proprietor, however, was about to rebuild it when I visited it in the autumn of 1838. All the parts may be measured by the scale of feet attached to Fig. 4.

Fig. 4.

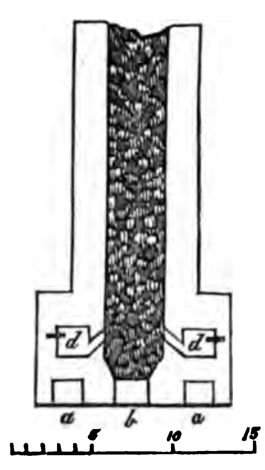
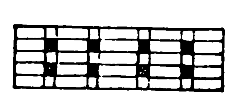


Fig. 5.



Besides the perpetual kiln that has been described in Richmond, another on the same plan exists in Lenox ; and these, so far as I could learn, are the only kilns of this kind that exist in the whole of Berkshire county. Nearly all the lime prepared there, is burnt in the old fashioned intermittent kilns. Indeed, I found among some of the lime burners there, a prejudice against the perpetual kilns; as if they did not accomplish the work thoroughly. These facts have surprised me, when I consider what a great and increasing demand there must be upon Berkshire for lime from other parts of New England; and being confident that it will be quite an easy matter to reduce the present cost of burning lime there, at least one half: and probably a great deal more. Mr. Haddsel of New Marlborough, who has burnt a vast quantity of lime stone for the last 30 or 40 years, (at present he burns about 12000 bushels annually,) and whose lime is considered very good in the Hartford market, told me that the cost of burning and preparing it for market would not fall much short of 25 cents per bushel. His kiln holds 700 bushels, and he consumes 40 cords of wood at a charge. Estimating the wood at $1.50 per cord, and this is probably too low, the cost per bushel is 8 1-2 cents. Dr. Jackson, in his second Report on the Geology of Maine, states the cost of fuel per bushel at Thomaston, where the old kilns are used is 8 cents. Now Professor Mather, in his second Report on the Geology of the First District of New York, states that lime is burnt in the perpetual kilns at Barnegat on the Hudson, where 720,000 bushels are annually prepared, for less than 2 cents per bushel:—the fuel costing less than one cent; and the labor of tending the kiln about the same; while the expence of raising the stone is trifling. In Connecticut, according to Professor Shepard, in his Geological Report, an intermittent kiln in Reading, that holds 1200 bushels, requires for a charge 40 cords of wood; another in Brookfield, that holds 700 bushels, requires 35 cords; and another in Derby, that holds 270 bushels, requires from 8 to 10 cords. If the wood be put at $2.00 per cord, the average price per bushel for these three kilns would be about 8 cents. But according to the same report, the perpetual kilns of Pennsylvania burn 700 bushels of lime with 8 cords of wood; and one and a half tons of anthracite: which, (putting the wood at $2.00 per cord, and the anthracite at $6.00 per ton,) amounts to 3 1-2 cents per bushel. In New York, Mr. Shepard says, they burn 2000 bushels of lime with 12 cords of wood: which, at the same price, is only a little over 2 cents per bushel. The proprietors of the perpetual kiln in Whately, that has been already described, estimate that their fuel, which is entirely wood, costs them from 3 to 4 cents per bushel; as stated in Mr. Nash's letter inserted on a former page.

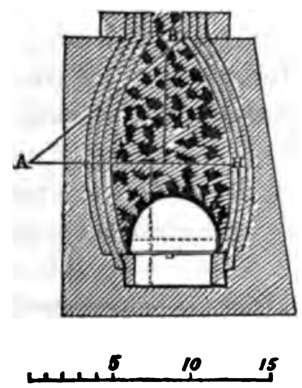
It ought to be mentioned that the fuel used at Barnegat is anthracite; which there costs $6.00 per ton: and this is undoubtedly more economical than wood. But the greater part of the difference in the cost of the fuel at that place and in Berkshire, results from the character of the kilns employed as the other facts above mentioned already prove. And if desirable to employ anthracite in Berkshire, it can probably be transported by rail road at so low a rate, as to render it practicable. It is said, also, that coal dust, which costs in New York $1.75 per ton, will answer well for burning lime. Does not this fact deserve the attention of the proprietors of those lime quarries in the eastern part of Massachusetts, that have been abandoned on account of the high price of fuel. Dr. C. T. Jackson, in his second Report on the Geology of Maine, states that it has been estimated, that even at Thomaston in Maine, the use of coal would reduce the price of lime from 8 cents per bushel, to 5, and perhaps 3 cents. And if so, why may not the preparation of lime be extensively resumed in the eastern part of Massachusetts?

From these facts I cannot but infer that Massachusetts, proud as she justly is of her skill in manufactures, is in this art very much behind the times. And I have no doubt that were those concerned to adopt all the improvements that have been introduced into the preparation of quicklime, in one

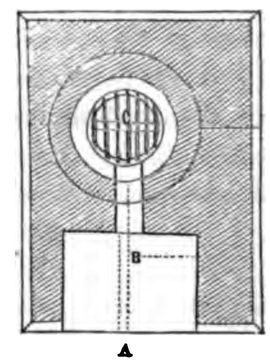
year the price of that article might be reduced one third, if not one half, *while the manufacturers would realize a greater profit than they now do.* This is particularly true of Berkshire county, which possesses an inexhaustible amount of this valuable material: but her citizens generally, it seems to me, are but little sensible of the treasure in their hands. Were only the fragments of pure limestone, that now lie useless around the marble quarries in West Stockbridge, Lanesborough, New Ashford, Adams, Sheffield, &c. to be burnt into lime, it would furnish a supply for the whole state for a great number of years. I am not aware that such a use is made of these fragments in a single instance; although the whole expence of quarrying is here saved. Is it said that there is little or no demand for the lime when prepared? But why not act on the commercial principle, that by increasing the supply, a demand can be created. Surely there is need enough for ten times more lime than is now burnt in Berkshire, in the region lying east of the county. And since rail roads will soon be in operation that can transport it thither, it becomes the interest of the inhabitants of that county to introduce all the modern improvements possible into its manufacture. Lime is sold at Barnegat for 6 cents per bushel: why can it not be prepared nearly as cheap in Berkshire? I confidently expect that the day is not distant when it will be: and then it will be in the power of our farmers, a good deal beyond the limestone district, to use it upon their land. At present the burning of lime is a business, so far as I could learn, not very profitable to those engaged in it in Berkshire county. But when its price shall be reduced one half, and ten times more is burnt, I predict that it will become profitable. I have been surprised to find how little limestone is burnt in that part of the state. It is a singular fact, that in most of those towns that have been most distinguished for the burning of lime, such as Washington, Hinsdale, and Peru, *no ledges of limestone occur*: but dependence has been placed entirely on the loose blocks that diluvial action has driven thither from the neighboring towns. And I have been assured that the inhabitants of some towns, which are based upon good limestone, transport most of the lime that they use from quarries in towns where very little exists in ledges, under an idea that they have no limestone where they live that is worth burning!

The use of peat in the burning of lime deserves the attention of those who own beds of the stone in the eastern part of Massachusetts. For the best European writers declare that it is decidedly more economical, and better in other respects, than wood. Figs. 6 and 7 are a vertical and horizontal section, the latter taken at the height of the grate,—of a kiln adapted for the use of peat.

Fig. 6.



Fig, 7.



A. Fig. 7, is an arch, and B, an embrasure, for introducing the peat and withdrawing the lime. The grate C, is composed of straight bars of iron resting upon a circular bar, which lies upon the brick work. The lining should be of fire bricks; though this is not indispensible. The sides of the kiln are curved; the radius of curvature being represented by the lines A H, A B, Fig. 6: whose length can be determined by the scale of feet at the bottom: and indeed, the same is true of every other part of the kiln; so that more particular description is unnecessary. Its height above the grate is about 18 feet, and its greatest width about 8 feet. In this kiln according to Dumas, (*Traite de Chemie applique aux Arts, Tome Deuxieme, p.* 488.) one cubic foot of limestone requires only two cubic feet of peat to burn it. Hence, next to anthracite, this appears to be the cheapest kind of fuel.

"When this furnace has been constructed," says Dumas "it should be left several days to dry slowly: when the fire is lighted, it should be done little by little, and gradually increased, lest the sudden contraction of the mortar should cause large fissures. The stone should be piled up in the kiln in the form of a hemisphere, so as to leave spaces of 2 or 3 inches between the fragments: the largest of these being collected near the center of the kiln, &c "—" When it is thus filled with stone, a muffled (*etouffe*) fire should be kept up on the grate for 10 or 12 hours. The smoke will blacken the stone very much to the top of the furnace. This operation, which is called the *smoking*, is intended to heat the whole mass by little and little. If heated too rapidly, the compact fragments would shiver in pieces by the rapid expansion of the water, and tend to choke the kiln."

Varieties of Limestone.

On the continent of Europe three kinds of quicklime are distinguished by the different sorts of mortar which they produce. 1. Fat lime: (*chaux*

grasse) 2. Meagre lime : 3. Hydraulic lime. The fat lime contains at least 90 per cent. of pure lime : But when the magnesia, silica, alumina, iron, and manganese, which it contains, amount to 20 per cent. it becomes meagre : that is, these foreign matters affect very much the mortar that is made from the mixture. When these foreign substances, however, are in considerably large proportion, the lime sometimes becomes hydraulic; that is, it will harden under water.

Fat Lime.

This being derived from an almost pure carbonate of lime, slacks with great energy and the evolution of heat ; forms a fine paste with water ; admits the addition of a great deal of sand ; is more easily laid on by the mason ; and therefore, is the most economical for common purposes. On all these accounts it is regarded as the best kind of lime ; and sought after the most. For it is not generally known in this country, that it does not form so hard and durable a mortar as the next variety.

Meagre Lime.

Although this kind of lime often slacks slowly and less perfectly than fat lime, and when water is added, forms a less perfect paste, and therefore, does not work so well with the trowel ; and as it takes up less water and bears less sand, is therefore more expensive, yet after all, it hardens with greater certainty, and to a greater degree, and forms a more enduring and stronger cement. It is especially valuable for the property which much of it possesses, of hardening in damp as well as in dry places ; and where mortar is exposed to the weather, it is by far the best. Nevertheless many of the circumstances mentioned above, produce a prejudice against this sort of lime, especially among brick layers.

It will be seen from the table of analyses of the Massachusetts limestones, that this variety of lime is very abundant among us, especially if we include under it, as is done by European writers, that which contains a large proportion of magnesia. I have had no opportnnity of trying but one variety of the meagre lime, and that is the kind that has lately begun to be burned in Whately. Having occasion to plaster a building upon the outside it seemed to me that this lime would be well adapted for the purpose. I tried it by mixing one part of unslaked lime with one part of sifted ashes, and one part of sand, and found it to produce a cement that spread well and became very hard, and at a few rods distance can hardly be distinguished from granite or sandstone. The outer coat, however, not having been put on in proper season after the first, does not adhere well. And although the Whately lime answers for outside work better than anyI have seen, yet I doubt whether in our climate, it be the best economy to cover the outside of buildings with any kind of calcareous cement. But if it be done, meagre lime is the best ; and I doubt not that several other varieties in the State will answer as well as that from Whately. I presume however, that when there is not more than 50 per cent. of carbonate of lime in a rock, it will not produce cement of much value.

It will probably surprise the inhabitants of Berkshire county, as it did me, to find that by far the largest part of the limestone burnt there, contains not less than 40 per cent. of the carbonate of magnesia. The fine looking stone burnt in the south part of New Marlborough and Tyringham, near the center of Lee, and in the east part of Lanesborough, from which places great quanti-

ties of lime are carried out of the county, and it is in high repute, is all genuine magnesian limestone. The same is true of the quarries in the eastern part of the state, at Bolton, Chelmsford, Littleton, &c. Now it is certain that magnesia does not form a paste with water; and yet, so far as I can ascertain, this kind of lime is preferred to that which is pure; because it becomes harder and is usually whiter. But I consider that there is yet too much doubt resting upon the use of magnesian lime in agriculture to render it expedient to employ it upon land when other lime can be procured. And from the analyses of our limestones that have been given, our citizens can now judge where the different sorts may be obtained. In respect to magnesian limestone, however, there is another important use to which it has not been applied in this state which I shall suggest in treating of the next variety.

Hydraulic Lime.

It has long been an important enquiry what ingredients are necessary in limestone to render it hydraulic; that is, to cause it to harden under water. Until recently but little success attended this enquiry: because the manner in which mortar is consolidated, was misunderstood. It was supposed to result from the absorption of carbonic acid from the atmosphere, whereby the lime was reconverted into a carbonate: so that the more completely this process was effected, the harder would the cement become. And this was thought to explain the reason why the ancient Roman cements, that are found in old ruins, are so hard. But upon analysis it was found that these mortars rarely contained much carbonic acid; and that in general they were harder, the less of this substance entered into their composition. (*Traite de Mineralogie, par Beudant, Tome Premier, p.* 690.) That mortars do, however, absorb carbonic acid on their surface, and that this is one of the causes of their induration, can hardly be doubted. But it is not the principal cause. Silica operates as an acid in mortars, and forms silicates of lime, magnesia, alumina, &c. and this probably is the principal cause of their consolidation. In this state silica exists in rocks, and to this fact chiefly they owe their hardness: and could the materials of mortar be mixed in such proportions as they exist in rocks, and under as favorable circumstances for induration, they would become as hard as the rocks; as in fact they do sometimes.

This theory shows us the use and even necessity of sand mixed with lime, to form good mortars. It shows us also, why it is better to have this siliceous matter exist naturally in the rock than to introduce it artificially, because nature mixes it more perfectly than art can do. But why should some mortars become silicates only in the air, and others with more facility under water? It is the opinion of distinguished chemists that the latter class are converted, when under water, into hydrated silicates; while the former, not undergoing this process, are more or less dissolved when immersed, and become mere anhydrous silicates in the air. But the analyses that have been made of these dif-

ferent varieties of limestome do not afford a satisfactory reason why some of them are hydraulic and some are not. Yet it is hence ascertained that certain ingredients besides the lime, are necessary to make them harden under water. It was formerly thought that this property depended upon the oxide of iron, or manganese, which they contained. But the numerous accurate experiment that have been made on the subject, prove that silica is the most important ingredient on which the hydraulic character depends. The results of all these experiments however, I give in the words of Dumas. "It follows," says he, "from all these facts, that silica alone is able to form with lime a combination eminently hydraulic: while magnesia alone, or a mixture of the oxides of iron and manganese, cannot produce a similar combination, but renders the lime meagre, without communicating to it the property of hardening under water. Synthetic experiments confirm the results of analysis; and prove farther. 1. That alumina alone has no more efficacy than magnesia in rendering lime hydraulic: 2. That silica is an ingredient essential to these varieties of lime: 3. That the oxides of iron and manganese, far from playing a part so important as some attribute to them, are on the contrary very often altogether passive: 4. That the best hydraulic lime results from a mixture of silica, lime, and magnesia, or alumina."—"We must, therefore, consider hydraulic lime as a silicate of lime, or a silicate of alumina and lime, or finally as a silicate of magnesia and lime, with an excess of base. These compounds placed in water produce hydrates; or other combinations of the hydrated silicate with the hydrate of the base in excess." (*Chimie aplique aux Arts, Tome Deuxieme, p.* 512.) More recently another distinguished chemist, Professor Mitscherlich of Berlin, says in respect to magnesian limestone for hydraulic cement, that "according to experiments in the small way, magnesian limestone merits the preference over the carbonate of lime." (*Elemens de Chemie par E. Mitscherlich, Tome Troisieme, p.* 120. *Bruxelles,* 1836.) Vicat also, recently inclines to the same opinion; and in our country, Professor William B. Rogers, the able state geologist of Virginia, has made numerous analyses of the hydraulic limestones of this country, from which he not only infers that magnesia operates favorably upon the hydraulic character, but even suggests that this property may depend upon the magnesia, rather than upon the silica. He finds that in all the hydraulic limestones which he has analysed, the carbonate of magnesia bears to the carbonate of lime the proportion of three to five: and he supposes that by this circumstance we may probably determine whether any limestone is hydraulic. Without doubting at all the accuracy of Professor Rogers' analyses and experiments, I confess that I do not know how to reconcile the principle, that the hydraulic character always depends upon magnesia, with the numerous analyses and experiments that have been made in Europe on the subject. In the

table below I shall give some of the analyses by Berthier of the best hydraulic limestones in France; most of which contain but a very small proportion of magnesia: and those which are artificial, and which are in high repute, contain none. Even the septaria of England, from which the famous Roman or Parker's cement, the best hydraulic cement in the world, is obtained, contains only one 200th, part of carbonate of magnesia; and a similar rock in France and Russia contains none. On the other hand, in some of the specimens analyzed by Prof. Rogers, the silica is less than two per cent.; and yet they form good hydraulic cement. We have then good mortar of this description, sometimes almost without silica, but containing magnesia; and sometimes without magnesia, but containing silica. Must we not hence infer, that the hydraulic character does not depend entirely upon either of these substances: but rather upon the mode or other circumstances of their combination with the lime: in other words, that they may replace each other.

I have annexed to the following table of analyses, the composition of some of those artificial hydraulic cements, which it is well known are frequently prepared in Europe, and with great success. I have also added the analyses of those limestones in Massachusetts, that so much resemble those from which hydraulic cement is prepared in other parts of the world, as to deserve a trial whether they will not also harden under water. It will be seen that the analyses of Prof. Rogers give the composition of 30 parts of the rock: while the others assume 100 parts as the standard. Berthier's analyses are given in the second volume of Dumas' *Chimie Applique aux Arts:* while those of Prof. Rogers are derived from his Report on the Geological Survey of Virginia for 1838.

Limestone moderately Hydraulic.

LOCALITIES.	Carbonate of Lime.	Carbonate of Magnesia.	Carbonate or Oxide of Iron.	Carbonate of Manganese.	(Argile) Clay.	Silica.	Alumina.	Alumina and Oxide of Iron.	Carbon.	Water.	Loss.
France (Loire)	90.0	5.0			5.0						
do (Ain)	85.8	0.4	6.2		5.4						
Eminently Hydraulic.											
France (Gard.)	82.5	4.1			13.4						
do	79.2	2.5	6.0		3.8	6.5			2.0		
do Senonches very famous.	80.0	1.5			1.0	17.0				1.0	
Virginia near Shepherdstown.	15.94	6.49				6.50		0.64		0.12	0.31
do do	16.76	11.76				0.77		0.35		0.13	0.20
do Jefferson county,	8.48	6.56				13.20		1.20		0.40	0.16
New York, Much used—	14.46	10.73				3.63		0.36		0.82	
Kentucky, Louisville,	16.51	7.25				4.54		0.79		0.37	0.54

Massachusetts Limestones perhaps Hydraulic.

No.	LOCALITIES.	Carbonate of Lime.	Carbonate of Magnesia.	Carbonate or Oxide of Iron.	Carbonate of Manganese.	(Argile) Clay.	Silica.	Alumina.	Alumina and Oxide of Iron.	Carbon.	Water.	Loss.
494.	Walpole,	70.30				29.70						
1942.	Becket,	58.31	28.61	1.24		11.84						
448.	Williamstown,	52.31	32.79	0.74		14.16						
496.	Stoneham,	59.28	15.71	1.21		23.80						
211.	W. Springfield, Paine's Quary,	93.48	0.90			5.60						
1737.	Springfield Chicopee,	86.80				13.20						
1941.	Middlefield, Cole's Brook,	56.25	31.56	1.12		11.07						
1944.	Sherbune,	60.43	29.84	2.36		7.37						
1918.	Concord,	77.33	1.19	1.65		19.83						
1946.	West Natick white crystalline,	72.10	7.50			20.40						
1950.	do yellow,	61.18	12.30	1.27		25.25						

Except the specimens from Springfield and West Springfield, which have been tried, I infer the hydraulic character of the Massachusetts limestones above given, from their composition alone. I am strongly suspicious that the fact that they are mostly of the primary class, and crystalline, will operate unfavorably. The great importance of finding such limestones in different parts of the state, will, I trust, lead to a fair trial of those that I have pointed out. This may be done at first on a small scale, without much trouble; and I should myself have tried them all, had my attention been specially called to this subject in season to obtain large enough specimens from the different localities. It would be particularly desirable to find such limestone in the county of Berkshire: And even should none of those prove hydraulic, which I have analyzed from that part of the State, it ought not to discourage search after those, which will prove so: for hydraulic limestones are usually of a poorer kind, such as in Berkshire would be passed unnoticed, as of no value. I have little doubt but those may be found there, which will set under water. At any rate, probably some varieties of the marl, that have been recently found in Berkshire, will make hydraulic cement, if burnt in a proper manner. For says Professor Mitscherlich, "a marl which contains from 13 to 19 per cent. of clay, makes a good hydraulic mortar; and if the clay contains an excess of silica, this circumstance increases the good qualities of the mortar." (*Elemens de Chemie, Tome Troiseme.*) Now by referring to the composition of the Berkshire marls, as given on a former page, it will be seen that marls of the description here mentioned occur there; and probably at almost any of the localities a part of the beds may be found containing the requisite proportion of clay, that is, of silica, alumina, oxide of iron, &c.

The only limestone in Massachusetts that has hitherto been employed for hydraulic mortar, is that at Paine's quarries in the west part of West Springfield: where large quantities have been manufactured within a few years past; and I understand it to form a good cement; although I

infer from analysis, that it is rather too pure a carbonate of lime. But not improbably the specimen analyzed was above the average in this respect. The specimen given in the general table of analysis from Chicopee, in Springfield, contains more clay and would probably make a good hydraulic cement. It occurs in the bed of the Chicopee river, just below the bridge at the Chicopee Factory village, where I presume is a large quantity. It has never been burnt at all for mortar; and indeed its existence there is hardly known; although large quantities of it, with the associated sandstone, have been got out for building factories on the bank.

The limestone at this place, as also at Paine's quarries in West Springfield, is mostly fetid, sometimes perhaps bituminous. But there is another variety occuring on the Chicopee, as well as the Agawam, which I suppose will produce an hydraulic cement far superior to any that has yet been made in this New England. But this I shall describe farther on.

Artificial Hydraulic Mortar.

When lime is not in itself hydraulic, it may be made so by mixing with it, either wet or dry, certain argillaceous matters, which have been burnt with the access of atmospheric air. Some of the clays used for this purpose in Europe resemble in composition the white clay from Martha's Vineyard, that is destitute of iron. Probably, however, the presence of iron will do no injury, and most likely many of our clays will answer. As to the kind of lime to be used, after what has been said there can be but little doubt but the magnesian would be much preferable. The proportion of the ingredients, and the precautions requisite to success, cannot be here given for want of room: but will be found in the works of Vicat, Dumas, and others. In this way, if in no other, can Berkshire and the eastern part of the state supply themselves with this mortar.

In Europe, however, ever since the days of Roman glory, it has been very common to employ, instead of clay, a kind of volcanic ashes called *Puzzolana;* which resembles burnt clay. In Holland great use has been made of a similar substance called *Tarras*, or *Trass*, which is decomposing basalt. The vescicular decomposing trap rock, not uncommon on the greenstone ranges in the valley of Connecticut river, appears to me so much like tarras, and puzzolana, that it would make a good substitute. I have accordingly subjected to analysis a specimen, from Mount Holyoke (No. 160.) in the north west part of Belchertown, where great quantities of it may be obtained in a state more or less approaching to powder. I have noticed the same substance along the eastern side of that greenstone range which extends through the eastern part of Deerfield and Greenfield. The following are the results of the analysis.

Water,	8.50
Silica,	53.70
Alumina,	13.00
Peroxide of Iron,	21.00
Oxide of Manganese,	0.19
Lime,	0.70
Magnesia,	0.15
Sulphur, (from pyrites) and Loss,	2.76
	100.

By Bergman's analysis, Puzzolana has the following composition:

Silica,	55 to 60 per cent.
Alumina,	19 to 20 "

Calcareous Matter,	5 to 6 per cent.
Iron,	15 to 20 "

The correspondence between this analysis and that which I have given, is near enough to show that in all probability both substances would answer almost equally well for hydraulic cement. If our clays, therefore, will not answer for this cement, here is a substance that can doubtless be employed.

Roman Cement.

In the year 1796, Messrs. Parker and Wyatts obtained a royal patent in England, for the manufacture of a peculiar kind of cement, which they denominated *aquatic cement*, and which subsequently obtained the name of *Roman Cement.* They were eminently successful, and others followed their example with the like success. It has become indeed, an important branch of business: and vast quantities are exported to foreign countries, where it bears a high price. It possesses the valuable property, after having been mixed with water, of hardening very rapidly, even in a quarter of an hour; whether in air or under water. Hence it is the most valuable sort of cement that is prepared from lime. In London, it is employed as a substitute for plaster of Paris, in preparing models: also for filling up crevices in walls, luting the joinings of aqueducts, restoring broken cornices, and other architectural ornaments, and for many other uses. Stones united with it become in a few hours as difficult to break through the joining, as in any other direction.

The material from which this valuable substance is obtained is a peculiar kind of concretionary limestone, occurring in nodules, of different sizes, which are usually traversed by veins of sparry carbonate of lime. These nodules, on account of being thus traversed, are called *Septaria.*

Now the valley of the Connecticut contains several localities of Septaria which are exceedingly like those of England. I have found them in quantity only in Springfield, on the Chicopee river; in West Springfield, on the Agawam, and at Wethersfield in Connecticut at a place called the Cove. The rock in the bottom of the river at Chicopee Factory village, may be seen spotted with them; and at the quarry a few rods east of Cabotville, on the south bank of the same river, great quantities of them may be seen, that have been thrown away. At this place I noticed some as large as a man's head; but generally they are much smaller. On the Agawam river, a little above Midneag Factories, the quantity of this peculiar argillo-ferruginous limestone appears to be greater than in Springfield: for here it forms layers between the strata of shale, of one, two, or three inches in thickness: which appears like clay that has been exposed to the sun, till it has cracked in all directions by desiccation. Upon the whole, I have a strong hope that

there will be no deficiency in the quantity of the material, should it be found to form the Roman cement, so as to make it an object to manufacture it.

On the Continent of Europe this sort of limestone has been sought after with great eagerness. I am not aware that it has been found except at two places in France, and one in Russia. I shall put down an analysis of a specimen from England and another from France, in order to compare these with the specimens which I have described in Springfield, whose composition is subjoined.

COMPOSITION.	English Septaria. (By Berthier.)	French Septaria. (By Berthier.)	Chicopee Factories. No. 1764.	Cabotville. No. 1763.	Agawam Manganesian No. 216.	Do. 2d Specimen. No. 1758.	Do. Argillaceous. No. 1759.
Carbonate of Lime.	65.7	61.6	46.06	43.69.	30.81	26.04	55.16
Carbonate of Magnesia.	0.5		27.35	39.35	18.33	13.45	22.21
Carbonate of Iron.	6.0	6.0					
Carbonate of Manganese.	1.6						
Silica.	18.0	15.0	20.97	13.57	45.33	54.00	15.56
Alumina.	6.6	4.8					
Oxide of Iron.		3.0	5.62	3.39	5.53	6.51	7.07
Water.	1.2	6.6					

Two of the above specimens from West Springfield, that are denominated *manganesian*, probably contain too much silica to make good Roman cement, or even the common variety of hydraulic cement; though they will harden considerably under water. As to the septaria from Chicopee and Cabotville, and the argillaceous limestone from Midneag, their composition corresponds essentially with that of the European Septaria, except that our rocks contain the most magnesia. But from the well known influence of this substance in causing lime to harden under water, the presumption is that its presence will rather assist than injure the hydraulic character. The earthy materials, made up of silica and alumina chiefly, exist in very favorable proportions. Suspecting the existence of manganese in most of the varieties, I subjected the second variety in the table (No. 1764.) to analysis, by fusion with soda, and obtained the following results.

Carbonate of Lime,	26.04
Carbonate of Magnesia,	13.45
Silica,	33.74
Alumina and iron,	15.13
Manganese,	11.64
	100.00

It ought perhaps to be mentioned that the English septaria, from which the Roman cement is prepared, is obtained from the London clay; a rock much more recent than the sandstone of this valley. But if the nature of the septaria be the same, and my experiments and analysis render this almost certain, it can make no essential difference from what part of the geological series it is obtained.

With these facts before them, I will not believe that the intelligent and enterprising inhabitants of the two Springfields will suffer this substance to lie much longer unnoticed. The interest which is taken in the discovery of a similar substance in France, may be learnt by the following remarks of Dumas, than whom scarcely a higher authority can be named. "This important discovery," says he, "must have the most happy influence on our great works of hydraulic architecture. No doubt but a substance so simple in its composition, may be found in many parts of the country. It is a matter of the highest interest that researches of this sort should be pursued with zeal: for their object is an immense improvement in the art of construction." (*Chemie Applique aux Arts, Tome Troiseme. p.* 525.)

Can it be that a material which excites so deep an interest among intelligent practical men in Europe, should not here awaken attention enough even to give it a fair trial, while we are yearly importing large quantities of the very same cement from England, which this rock would produce; and that too at a great expense? Suppose it yields a cement inferior to the English: yet may we not infer almost certainly, that it will produce a hydraulic mortar superior to any that is now prepared in the state. May not the man therefore, who first successfully brings it into the market, hope to realize a valuable pecuniary profit? At any rate, it can be tried at a very little expense on a much larger scale than I have done. But let me caution any one who shall undertake it, against being too speedily discouraged, should the first efforts prove unsuccessful. Although this limestone is burnt in the same manner as the other sorts of limestone, yet the management of the fire requires peculiar attention; lest the stone begin to fuse, which will render it totally unfit for cement. On the other hand, a temperature too low, will produce a meagre lime, that is not hydraulic. The process also must be carried through when it is begun, without stopping: as a suspension of the heat for a time, when the carbonic acid is partly driven off, will prevent the expulsion of the rest by a subsequent application of heat. But difficulties of this sort can be overcome by perseverance:—a virtue which the inhabitants of New England know well how to exercise.

10. *Argillaceous Slate.*

A more common name for this rock, at least for the most useful variety of it, is *roof slate*; be-

cause it is used for forming the roofs of houses. I have been inclined sometimes to regard the ranges in Quincy, Watertown, Charlestown, and Cheslea, as a fine grained variety of graywacke; but this question may be more properly considered in the scientific part of my Report. At any rate, this rock, in the towns above mentioned, does not split into layers sufficiently thin for roofing. But it is valuable for gravestones, the covering of drains, flagging stones, &c.; and for these purposes it is extensively wrought in Quincy, Charlestown &c.

Novaculite.

This is a variety of argillaceous slate which is known in the arts under the name of hone, oil stone, tu:key stone, and whetstone. It exists in beds of argillaceous slate in Charlestown, Malden and Quincy. It is not however, of a very good quality; and I am not aware of its being used for hones, or even for whetstones: although it might answer the purpose, if better materials could not be found elsewhere. M. Godon, in his account of the geology of Boston and vicinity, says that a compact feldspar is found there perfectly analogous to the turkey stone. I have found a variety of this mineral in Newbury, which I apprehend, corresponds with that described by this writer, and a specimen may be seen in the collection; but no fair trial that I know of has been made to employ this stone as a hone. (No. 1206.)

Roof Slate in Woreester County.

The range of slate exhibited on the Map in the towns of Boylston, Lancaster, Harvard, Shirley and Pepperell, is associated with the peculiar mica slate that contains the Worcester coal. It answers for roofing in some parts of the bed and has been quarried for this purpose in Lancaster. It has been wrought considerably in Harvard and Pepperell for gravestones; and is transported a considerable distance for this purpose. The stratum is narrower near the north line of the State; but I have found no time to ascertain how far it extends into New Hampshire.

Connecticut River Slate.

Although a large part of Bernardston is represented as composed of this slate, yet its characters are not perfectly developed till we pass into Vermont. In Guilford, Brattleborough, Dummerston, and even 50 or 60 miles farther north, it produces an excellent material for roofs, writing slates, &c.: and extensive quarries are opened in it in those towns. The best slate used in Massachusetts probably comes from this range. In Bernardston it is quarried to some extent for gravestones.

Berkshire Slate.

The mica and talcose slate of the western section of the State, pass gradually into roofslate, but in most instances the characters of the latter are not very perfectly exhibited, until we have entered New York. There, however, in Hoosic, and other towns, it is quarried extensively for roofing; and the western part of Massachusetts is always sure of a supply of this valuable material from that quarter if not within its own limits.

11. *Graywacke.*

For the most part, this rock furnishes a coarse stone only fitted for a common wall; but sometimes its stratification is so regular, and its grains are so fine, that it answers well for underpin-

ning, step-stones, &c. It is quarried I believe in Brighton, and some other towns in the vicinity of Boston. At Pawtucket, on the Rhode Island side of the river, is an extensive quarry of a fine grained and slaty variety, which I should judge would form a good flagging stone; and immense quantities have been taken away for this object and for other purposes. On Canonicut island in that state, is also a valuable quarry of this rock.

Graywacke is sometimes beautifully amygdaloidal; that is, it contains numerous rounded or almond shaped nodules of some other mineral. In these instances, however, the base of the rock is rather *Wacke*, than graywacke. This wacke (which resembles indurated clay,) often forms the cement of graywacke. In Brighton it is of a reddish color, while the imbedded nodules are sometimes white, and often consists of white feldspar with epidote, which is of a lively green color; and these substances are not only in rounded massess, but in veins of irregular shape. The rock is hard and admits an imperfect polish. It then resembles porphyry and is elegant. A fine example of this is in possession of Hon. H. A. S. Dearbon, forming a pedestal for the bust of his father. It is only slightly polished, but would generally be mistaken for porphyry.

A similar amygdaloid occurs in Brookline, Newton and Needham. A variety still more beautiful is found in Hingham. The color of the base is chocolate red; and the nodules are red, green and white. Large blocks can be got out.

I think upon the whole, however, that the finest amygdaloid occurs in Saugus, on the hill a few rods east of the meeting house. The base is a pleasant green, and the nodules white compact feldspar, generally spherical, and thickly interspersed. I have little doubt that large blocks can be obtained at this locality; but as the base is softer than the nodules, it can be only imperfectly polished.

12. *New Red Sandstone.*

This rock occurs in Massachusetts, only in the vicinity of Connecticut river; along which on both sides, ranges extend from Middletown, Ct. to Vermont. It affords large quantities of good stone for building and other purposes. Some of the numerous varieties of this rock are slaty; and either of a red, gray, or black color. These varieties furnish good flagging stones; and the side walks of all the principal places along the river, are chiefly covered by them. In the more common varieties, the strata are from six inches to two feet or more in thickness: and for the most part the color is red, though sometimes gray. From these thicker strata is obtained most of the rock of this formation used in architecture. The most delicate variety occurs in Longmeadow and Wilbraham. It consists simply of an almost blood red sand, cemented probably by iron. It is remarkably uniform in its color and composition; and forms a beautiful and most valuable building stone; though liable to be easily injured and sometimes disintegrating by exposure. The quantity of this rock is inexhaustable, and it occurs from three to five miles from Connecticut river: the intervening region being nearly level. A great number of quarries are now explored; but I have no means of determining how great is the demand for the stone. The celebrated Chatham quarries, on the bank of the Connecticut river, in Connecticut, are opened in the same kind of rock, although a coarser variety.

Another variety of the new red sandstone, quarried in many places in Massachusetts and Connecticut, is coarser than the Longmeadow stone; but being harder, it is more enduring, though less elegant. This variety is quarried extensively for the Farmington Canal, in the sandstone range south of Mount Tom in West Springfield; also in Westfield and Deerfield. A gray and rather coarse variety is used in some places, e. g. in Granby, Mass. This indeed, with the other varieties mentioned above, forms excellent underpinning, door and window caps, and foundations and door steps; and like the Berkshire marble, they are sometimes wrought into sinks and other similar articles. The ease with which the rocks of this formation are wrought, forms a great recommendation; and, were they as enduring as gneiss and grañite, these latter rocks would soon be neglected.

On the north bank of Connecticut river in Gill, at a place called the Horse Race, is a quarry of gray micaceous sandstone, which forms excellent flagging stone. Slabs of very large size can here be obtained. In the southwest part of Montague, 100 rods from Connecticut river, a quarry in red sandstone has recently been opened, which appears to me to bid fair to become one of the most valuable in the state. Most of the rock is slaty, and some of it is divided by cross fissures into joints of such form and regularity, that excellent flagging stones and underpinning may be split out at once; and need neither smoothing nor hammering upon the edges. The stone forms a hill of some 30 or 40 feet elevation, and of great length. Being so near the river the means of transportation are at hand.

Suggestions as to the causes of decay in rocks used for construction; and the means of judging beforehand as to their durability.

The question is often asked if the geologist can determine by examination or tests, whether a rock will be liable to disintegration upon exposure to air or water: And it is a very difficult question to answer satisfactorily. Most of the remarks which I shall make on the subject will be mere suggestions; which will require the test of experiment before they can be of much practical importance.

In opening a new quarry, if any of the rock has long been exposed to the weather, it can be seen what is the effect of atmospheric agents: and if disintegration has hardly begun, a favorable prognosis may be given as to the durability of the rock. But if the surface has been deeply acted upon, it is unfavorable. This is the surest mode where it can be adopted, of settling this question. Nor in the present state of chemical geology, do I believe it possible to determine with certainty the durability of a rock without an actual trial. Yet the chemical constitution of a rock will enable us sometimes to predict whether it will be liable to disintegration.

Of all the ingredients in rocks, probably iron in some form, most exposes it to decay. If this exist as a protoxide, or a sulphuret, exposure to the atmosphere will most probably convert it into a peroxide: and if the quantity be considerable, this will produce disintegration of the rock. Sometimes, however, this change only communicates the stain of iron rust to the surface of the stone, while its solidity and durability are hardly affected. An example of this sort may be seen in one of the churches in Quincy, built of the sienite of that place. When built, the stone was of a good color: but it has become so much stained with iron, as very much to mar its appearance: yet I believe there is no disintegration. But in many places in the west part of Essex County, as in Reading and Topsfield, I have noticed the sienite to be crumbled down, and from its ferruginous aspect, I presume this proceeds from some metamorphosis of the iron. I impute the disintegration of some of the red sandstone, used for construction in the vicinity of Connecticut

river, to the same cause. Yet as the iron in this rock appears to be peroxidized when quarried, probably the disintegration may proceed from the conversion of the peroxide into the hydrate; or of the hydrate into the peroxide.

In the limestones of Berkshire county, the iron exists in most cases probably in the state of a protocarbonate; and this substance is very liable to decomposition. Probably, therefore, those limestones that contain the least iron, will form the most enduring and valuable marble. Analysis lends probability to this suggestion. For the best marbles of Berkshire County are almost destitute of iron; as the following statement will show.

Marble of North Adams, contains of iron			a trace
do	Lanesborough,	1st specimen	do
		2d do	0.22 per cent.
do	West Stockbridge,	Fitch's quarry,	0.14 "
		Boynton's do	0.08 "

The two first specimens probably may contain as much iron as the three last: for I did not attempt to estimate it.

I consider the presence of a large quantity of magnesia in limestone as unfavorable to durability. For it is a general principle in chemical combinations, that the greater the number of ingredients in a compound, the more feebly are they held together; and a magnesian carbonate is much more complex than a simple carbonate of lime. Observation and analysis sustain this view. For it appears that with the exception of the clouded marble of Great Barrington, (of whose durability I have not been informed,) no valuable marble in Berkshire contains much magnesia. Again, we find that nearly all the valuable marbles hitherto explored there, are found along the western part of the county; while the limestones of the eastern portion, that abound in magnesia, afford but few. Besides, among these magnesian limestones it is common to see their surface crumbled into powder; while nothing of the kind is witnessed among the pure carbonates. This disintegration is most striking in the town of Canaan, lying south of Sheffield.

It is well known that potassa exists in feldspar in large proportion: and that this mineral frequently decomposes, and is converted into porcelain clay. In this process the potassa dissolves and carries away a large proportion of the silica; leaving most of the alumina. Must we not impute many instances of the disintegration of granite, to the agency of the potassa; since the other ingredients are quite inert? The same may be said of sandstone composed of fragments of granite and gneiss. I confess, however, that I see no reason why one variety of granite should easily decompose, while another, with as much feldspar, should resist the atmospheric agency of thousands of years.

Wherever carbonic acid is evolved from great depths in the earth, where the temperature is high, and forces its way through the rocks, it cannot but dissolve more or less, some of their ingredients, and render them more liable to disintegrate. This cause of decay applies more particularly to countries in the vicinity of volcanos. Yet it is thought by some geologists that carbonic acid gas does percolate through the soil in many regions far removed from volcanic action. I have sometimes been led to resort to this agency, to explain the fact, that the only granite occurring in Berkshire county, in the western part of Clarksburg, should disintegrate so easily. I have not noticed in its feldspar a tendency to decomposition: and yet its bowlders, that are strewed for 20 miles over the hills and valleys in a southeast direction, are almost incessantly crumbling to pieces. That free carbonic acid has pervaded the rocks of Berkshire county, in early times, in a very remarkable degree, and that it has even undergone decomposition while in them, I shall endeavor to show in another part of my report: but whether the process is now going on to any extent, I have no facts to determine; yet there are some indications that an extensive fault exists along the western part of that county.

If the views which I have presented are founded in truth, then benefit might sometimes be derived from chemical analysis in judging of the probable durability of rocks for architectural purposes. This is particularly true of limestones. But I will not farther enlarge on a subject on which I am able to cast so little light.

13. *Clay for Bricks.*

The clay that has been already described as serviceable in agriculture, is employed almost every where for making bricks. There are but very few towns in the state, and those very mountainous, where this clay does not occur in a state more or less pure. I regard all of it as belonging to the diluvial formation; and it seems to have been deposited in every basin, where the retiring diluvial waters were kept quiet by the surrounding hills. Consequently we find it at very different levels; and having been derived from the rocks in the vicinity of its deposits, its color and composition will somewhat vary. In most instances its color is bluish, passing sometimes to greenish. But in the eastern parts of the state, as at Lowell, Kingston, Sandwich, &c. its color is nearly white; though I am not without strong suspicion that most of the clay in Plymouth and Barnstable counties belongs to an older deposit, whose type exists on Martha's Vineyard, and which I do not include in the diluvial clays that are described above.

Nearly all the clays in Massachusetts, except the white clay of Duke's County, contain a large per cent. of iron in the state of protoxide. When exposed to strong heat, this passes to the state of peroxide, or the red oxide; and this is the reason why all the bricks made in Massachusetts are red. In some parts of the world bricks are made of clay destitute of iron, and these when burnt, are white, or nearly so. These are denominated fire bricks, because they will endure so powerful a heat without vitrification. The same clay is employed for pipes and white earthern ware; and the most delicate variety is used for the manufacture of porcelain. Very little clay in Massachusetts, except the white variety on Martha's Vineyard, will answer even for

fire bricks; because it nearly all contains iron. The non-ferruginous clay of Martha's Vineyard, however, is quite abundant. I give below its analysis, as well as that of a specimen from an excavation in granite, made a few years ago, a mile northwest of the meeting house in Norwich; where is a vein of blende. The feldspar of the granite is more or less decomposed; and if the quantity is large enough, it will doubtless answer well for the purposes above named; even for porcelain; as its composition corresponds essentially with that of European porcelain clays. In neither of the specimens could I detect a trace of iron: but I selected those which were apparently most pure.

	(No. 145.) Norwich Clay.	(No. 144.) Gay Head Clay.
Water,	8.00	9.00
Silica,	53.40	62.26
Alumina,	36.26	29.31
Lime,	0.24	0.18
Magnesia,	0.68	0.45
Manganese,	0.20	0.15
Loss,	1.22	Excess—1.35
	100.	100.

Since it is not every white clay that is destitute of iron, as an examination of Nos. 142, 143, will show; it may be well to mention an easy method of determining whether a clay contains iron in the state of protoxide. If it does, it will become yellow, or red, when exposed to a strong heat; but if it does not, its white color will remain.

Precious Stones or Gems.

Although but few gems have yet been wrought that are natives of Massachusetts, yet the list of such as exist there in greater or less quantity, is by no means contemptible.

Quartz.

The most common variety of this mineral, that is employed in jewelry, is the *rock crystal, or pseudo diamond*, which is the limpid crystal. When cut, it exactly resembles pure glass, but is much harder. It may be used for a great variety of ornaments, but on account of its wide diffusion, its pecuniary value is not very high. Although it is met with in almost every part of Massachusetts, I shall refer only to two localities. In the south part of Pelham large quantities of quartz crystals occur, and some of them will answer for the lapidary, (No's. 1097 to 1101.) But these crystals are inferior to those found in the south part of Willamstown, on the farm of a Mr. Phelps. (No. 1987.) The crystals are numerous at this spot, but they are generally of a small size.

Yellow Quartz, or Citron, or Occidental Topaz.

I have met with this variety only at the lead mine at Southampton, and there but rarely. It is said, however, to occur also at Middlefield. When cut it can often hardly be distinguished from topaz.

Smoky Quartz, or Smoky Topaz.

This is quartz crystal that appears as if penetrated by smoke. It makes a delicate ornamental stone when polished. I have found it in crystals in Goshen and massive in Williamsburgh. A coarse variety is not uncommon in large grained granite. I am indebted to J. S. T. Ames Esq. of Cabotville for a pretty cut specimen from South Brookfield. From Canton in Connecticut, I have a crystal six inches in diameter.

Amethyst, or Amethystine Quartz.

The most valuable variety of amethyst is a violet colored sapphire. But the common amethyst is nothing more than colored quartz. It is met with sometimes in the trap rocks of the Connecticut valley, as on Mount Holyoke and on Deerfield mountain. (Nos. 1192. 1193.) It has been found also in gneiss of a delicate color in Franklin by Mr. Mortimer Blake. (No. 2508.) I have seen it also in rolled masses in Amherst.

Rose Quartz.

This differs only by a shade of color from the amethyst. It would be much esteemed in jewelry were it not that it is liable to fade. Yet a faded specimen may be in a measure restored by being placed for some time in a moist place. This variety occurs in Blanford, Chesterfield, Chester, Williamsburgh, and Chelmsford: but at none of these places is it particularly beautiful. (Nos. 733. to 735.)

Prase.

Prase is only a green variety of quartz, of no great value as a gem. I have noticed it only in bowlders of graywacke in Brighton, Dorchester, and Dover. (No. 391.)

Hornstone.

I know of but one variety of this mineral in Massachusetts that is delicate enough for the purposes of the lapidary: and that is the light green specimen (No. 2509.) from Pelham and Amherst, where it has been found only in bowlders. From the specimen in the state collection, it will be seen that if polished, it would form ornamental articles of rich appearance. This specimen moreover is interesting from its historical associations; it being the identical block out of which the followers of Shays manufactured flints during his insurrection against the Government. I am indebted for it to O. M. Clapp, Esq. of Amherst whose father preserved it. It is fully equal to flint for striking fire.

Chalcedony.

Almost all the varieties of this mineral, viz. common or gray chalcedony, cacholong or the white variety, and carnelian, or the flesh colored, are found in the trap rocks in the valley of the Connecticut, particularly in Deerfield. The specimens, however, are not usually large. But in

the primary regions of the state, and associated with mica slate, we find large rounded masses of chalcedony, which is usually mixed with some other variety of quartz; as at Chester, Tyringham, Conway, and Amherst. Were this mineral in demand by the lapidary, I doubt not but some of these localities would afford handsome specimens.

Jasper.

This mineral, reckoned among the precious stones by the ancients, is not uncommon with the porphyry of the eastern part of the state. Saugus has long been known as its principal locality. Specimens from that place are, indeed, more beautiful than any which I have met with from other parts of the state: though were I writing the scientific history of the mineral, I might be permitted to doubt whether it is the genuine jasper of mineralogists. But as it greatly resembles true jasper, it may, without practical error, be considered such. Its color is red, and sometimes it is traversed by white veins which makes it resemble the striped jasper of Egypt. (Nos. 388. to 390.) Several other varieties of this mineral are found in Lynn, and in the vicinity of the Blue Hills. Indeed, almost all the sea beaches from Boston to Sandwich abound in pebbles of this character From them all a beautiful collection might be made out.

Agates.

Agates are composed of the different varieties of quartz, arranged in spots, veins, or stripes, so as to produce a pleasing diversity of colors. These are not uncommon in Massachusetts. Some have been found in the south part of Deerfield, (No. 1191.) from six to nine inches across, composed of concentric layers of chalcedony, carnelian, &c.: and sometimes these constitute a geode lined with crystals of amethyst. In Conway and Amherst, the different varieties of quartz, such as hornstone jasper, and chalcedony, are agatized; so that if polished they would be beautiful. (Nos. 737 to 745.) In Rochester I have found large masses of a brecciated agate, which admits of a good polish, (No. 1103.) and this occurs more or less in a northerly direction almost to Middleborough: and southeasterly to Fairhaven. I doubt not but some fine specimens might be found in that region.

Satin Spar.

This fibrous variety of limestone, which would be more valued were it harder, exists in considerable quantities in at least two places in Massachusetts. At Newbury it occurs in connection with serpentine, and is of a white color. At West Springfield, it is in veins traversing red slate, which has imparted to it a reddish color. The pearly lustre of this mineral makes it a favorite for the beads of necklaces and for ear-rings.

Apatite.

In color and appearance this mineral resembles several more valuable precious stones; especially the beryl: but it is much softer and consequently much less valuable. It occurs at several places in the State; especially in the limestone beds of Bolton, Littleton, and in the mica slate of Norwich, &c. But I have seen none that would be elegant when cut and polished. (Nos. 531. 728.)

Amber.

It ought not to be forgotten that fragments of this mineralized resin, which makes very pretty ornaments, has been found at Gay Head ; and a mass on Nantucket weighing a pound: and that the tertiary deposits of those islands are precisely of the character most likely to yield this substance.

Fluor Spar.

I know of no locality of this mineral in the State that furnishes specimens of much size: But those at the lead mine in Southampton are of a deep green and purple color and beautiful: and should that mine be more extensively explored, there can be no doubt but fine specimens of fluor would be obtained. It is used chiefly for vases.

Sappare or Kyanite.

Good specimens of this mineral are very easily mistaken for the blue sapphire ; from which however, it is very easily distinguished by its inferior hardness. In this country it has scarcely been employed in jewelry; but in France and Spain it is cut into forms adapted for rings, broaches, &c. Although not uncommon in this state, the only locality where its color is fine enough for this purpose, is Chesterfield, where it is often found very beautiful.

Feldspar.

Adularia is the variety of this mineral most frequently used in jewelry. It forms the ***Moon Stone***, ***Sun Stone***, ***Water Opal***, &c. In Brimfield, Sturbridge, and Ware, it forms numerous laminar nodules, which would undoubtedly answer well for ornamental purposes.

There are two localities in the State of green feldspar : viz. Beverly and Southbridge. The latter is a light green adularia, and answers well for ornaments ; as the polished specimen No. 1086 will show. That found in Beverly is of a still deeper and richer green color.

Some of the feldspars of Essex County, are of other rich colors ; as brown, bronze, &c. and it seems to me they would be elegant if cut and polished.

Iolite.

This mineral, which somewhat resembles sapphire in color, occurs in the gneiss of Brimfield. But whether in masses large enough for ornamental purposes, is perhaps uncertain. Yet the locality has yet been but imperfectly explored.

Silicate of Manganese, or Manganese Spar.

This beautiful ore takes a good polish, and is sometimes employed in jewelry for inlaid work. It occurs abundantly in Cummington ; but has never to my knowledge been cut and polished in this country, except a few specimens by J. S. T. Ames, Esq.

Garnet.

Two varieties of the garnet of Massachusetts, vie in beauty with those from any part of the world. The first is the essonite, or cinnamon stone; so called from its brown color. Splendid crystals of this mineral are found in the limestone of Carlisle, accompanied by scapolites, actynolite, &c. Without polishing, these crystals form splendid gems. Less beautiful specimens are found in limestone in Boxborough.

The other variety is the Pyrope. And this exists in Worcester county in great quantity, in a belt of country several miles wide, embracing the towns of Sturbridge, Brimfield, Wales, Holland, Ware, Brookfield, Barre, &c. The same garnetiferous gneiss that contains this mineral in Massachusetts, I have traced nearly to Long Island Sound. The most perfect specimens of this pyrope occur at an excavation made in Sturbridge a few years ago, in search of plumbago, on the farm of Mr. Morse, one and a half miles south of the meeting house. These are so fine that I have placed some specimens in the Government collection that have been cut and polished and were they set in foil, they would advantageously compare with pyrope from almost any part of the world. Though the rock abounds with the mineral at this spot, the best specimens are obtained from the thin layers of plumbago which exist there. There is little difficulty in finding specimens large enough and of good color in many places: but they are liable to be filled with fissures. Those in the plumbago have more solidity. I think the time will come when this beautiful mineral will be extensively sought after in the region above described. At present there is no demand for it, because there is not, to my knowledge, a lapidary in New England.

Spinelle.

The blue or black spinelle has no commercial value, not being used for jewelry. But the red spinelle, or ruby is extensively employed. Both varieties have been found at Boxborough, Bolton, and Littleton, in the limestone: but as the red variety is very rare, it is unnecessary to dwell upon the subject.

Tourmaline.

All the varieties of color which this mineral any where exhibits, viz. blue, red, indigo, black and white; and all mixtures of these colors, are found in the tourmalines of Chesterfield and Goshen. These colors too, are very rich: but hitherto the crystals found there have abounded in cracks, which have injured them for cutting; although they form elegant cabinet specimens. Some of the specimens, however, would admit of being wrought. The red tourmaline is said also to occur with the essonite garnet, in the limestone of Carlisle.

Beryl.

The recent discovery of a rich locality of this mineral in South Royalston, enables me to place it as the first and most abundant of all the gems of Massachusetts. The specimens in the State Collection exhibit it in its natural state, as well as cut and polished by the lapidary. When set in gold, it is often much richer in appearance than the common beryl, that goes by the name of *aquamarine*. Its color often approaches nearer to the genuine emerald, though some specimens have the peculiar blue color of aquamarine. Sometimes, though rarely, the color is a yellowish green, very much like the chrysolite. Hundreds of specimens have already been obtained from this spot; and the prospect is, that a vast many more may be obtained. They occur in a vein of coarse granite, 10 or 12 feet wide, traversing gneiss; and the purest beryls are in the quartz. It ought, however, to be remarked, that only a few of the specimens are free enough from fissures to be advantageously cut. Yet considering the large number of fine cabinet specimens that have been, and probably can be, obtained there, I apprehend that no locality of beryl hitherto discovered in this country, can compare with this. My attention was first directed to it by Alden Spooner Esq. of Athol; who generously furnished me with several fine specimens.

Another new locality of beryl, less prolific however, and furnishing far less beautiful specimens, is in the extreme west part of Barre, in a coarse granite vein, similar to that in South Royalston. The State collection contains specimens. Several other localities exist in the State; as, Norwich, Goshen, Chesterfield, Pelham, Warwick, Fitchburg, &c.: and from some of them, now and then a specimen has been obtained nearly equal to those from Royalston: but in general they are coarse and scarcely translucent.

4. USEFUL METALS AND THEIR ORES.

I shall begin with the metal that is most wide spread, abundant, and useful.

1. *Iron.*

Arsenical Iron and Carbonate of Iron in Worcester.

In the town of Worcester, in mica slate, is a bed of these ores, which was explored to some depth, a number of years ago, in search of the precious metals. A little galena or lead ore is found also, in the same mine. As the excavations are now nearly filled up, it is impossible to judge of the extent of this bed.

Arsenical iron is seldom explored for the purpose of getting malleable iron from it; although it is sometimes employed for the arsenic it contains, and for the preparation of sulphuret of arsenic. The carbonate of iron is an excellent ore: and has received the name of steel ore, because it may be readily converted into steel.

Carbonate of Iron and Sulphuret of Zinc in Sterling.

This is a bed, in mica slate, just like that at Worcester: and was extensively explored forty or fifty years ago, for the same purpose which led to the opening of that bed, viz. the discovery of gold and silver. The carbonate is the most abundant ore, and lies scattered about the excavation, in considerable quantities; although the sulphuret of iron is common, which is sometimes arsenical. A reddish, foliated sulphuret of zinc also occurs here, in considerable quantity, and some sulphuret of lead. Whether this mine will be found worth exploring, it is difficult in its present state, to determine. If it afford the carbonate of iron in large quantities, it will certainly repay the effort. It lies about a mile and a half southeast of the center of the town.

The most important one at the above localities being carbonate of iron, I have subjected specimens to analysis with the following results. From 100 parts of the ore from Worcester (No. 783) I obtained,

Silica &c.	3.66
Proto Carbonate of Iron,	59.28
" of Manganese.	1094
Carbonate of Magnesia,	25.80
Loss,	0.32
	100.00

A specimen from Sterling (No. 785) yielded,

Silica,	0.69
Proto Carbonate of Iron,	81.69
" of Manganese,	4.42
Carbonate of Magnesia,	12.58
Loss,	0.62
	100.00

Carbonate of Iron in West Stockbridge.

At the bed of hematite iron ore in West Stockbridge, there is frequently found a stone of a light gray color, (No. 1689) which used to be thrown away as of no value. But its great weight attracted attention; and upon trial it was found to be an excellent ore of iron. On analysis I find it to be a granular, almost pulverulent, and quite pure, carbonate of iron. It yielded as follows:

Proto Carbonate of Iron,	87.19
Carbonate of Magnesia,	5.21
do. of Manganese,	2.46
do. of Lime,	1.41
Silica, alumina, &c.	2.81
Loss,	0.92
	100.00

This ore exactly resembles a specimen of the Sphaerosiderite from Hesse in Germany,* and can hardly be distinguished from the compact carbonate of iron found in some of the coal fields of this country. If it exists in much quantity at West Stockbridge, or at any of the beds of iron ore in Berkshire County, it deserves the attention of the enterprizing men who are there engaged in the manufacture of iron. But I cannot conceive why this ore should not yield steel at once as is done in the process by which German Steel is prepared. Since I ascertained the composition of this ore, I have not been able to visit the iron deposits of Berkshire.

* This specimen is No. 153 of a collection of rocks from Germany in the Cabinet of Amherst College. As this collection will probably be permanently accessible, I shall for the sake of comparison, several times refer to it in the progress of this report. An Economical Collection from Europe in the same Cabinet will also be referred to, occasionally.

Carbonate of Iron in Newbury.

As one passes from Newburyport to Kent's Island in Newbury, just as he arrives at the northern margin of the salt marsh surrounding the island, he will notice abundant fragments of a white rock, coated over with iron rust. Suspecting it to be carbonate of iron, I obtained a specimen (No. 176) and have subjected it to a hasty analysis with the following results:

Carbonate of lime,	45.67
Carbonate of magnesia,	8.97
Proto Carbonate of iron,	21.76
Proto Carbonate of manganese,	16.10
Silica and alumina,	3.34
Loss,	4.16
	100.

Specific gravity, 2.94.

The small quantity of iron in the specimen above analyzed, and the abundance of lime and magnesia, leave one in doubt whether it ought not to be regarded rather as a magnesian limestone containing a large amount of iron and manganese. A more important question is, whether, with so little iron, this mineral can be profitably wrought. And yet some of the ores of spathic iron in Europe that are smelted, contain only a little more than 20 per cent. of the carbonate of iron. This ore is regarded in Europe as one of the most valuable of all the ores of iron, especially for the manufacture of steel; the well known German steel being obtained from it: and the character of most of the substances mixed with it in Newbury, especially of the lime, will probably render any other flux unnecessary in working it, unless it be clay. At any rate, as I noticed the quantity of the mineral to be very great at the spot above named, and as I may not have selected the richest specimens to be found there, I have thought it would be best to call the attention of the public to the locality.

Chromite of Iron.

This valuable ore is disseminated in minute grains through most of the serpentine in Massachusetts, west of Connecticut river. But as yet only two places are known where it exists in veins of sufficient quantity to deserve attention. One of these is in a bed of serpentine five miles northwest of the meeting house in Blanford, on the old road to Becket. It occurs there in tuberculous masses, or perhaps a vein, of only a few inches in diameter; and Dr. H. Holland of Westfield informs me that he has ascertained that it contains only about 30 per cent. of the oxide of chrome. But a few miles farther north, in the west part of Chester, near the rail road, and on one of the branches of Westfield river, he has discovered a vein of much greater extent, which bids fair to afford enough of the ore for the purpose of manufactory into the useful chrome salts. Dr. Holland has furnished me with the following description of this ore.

" The chrome ore," he says, " appears only in the eastern portion of the serpentine. I have found three distinct 'out-cropping' veins of the ore, or more properly *couches*, crossing the ser-

pentine, which is schistose and deep green, east and west, from 5 to 18 inches in width. I had a man blast one of the couches, and with a few hours' labor procured some 1200 pounds of the ore. I have one mass very pure of 60 pounds."

"I have tested the mineral as accurately as possible to determine its comparative value, and found it upon analysis, similar to Uralian chromite of iron, giving from 52 to 53 per cent. of oxide of chrome, as it enters into composition, a protoxide. The iron is from 33 to 35 per cent. a peroxide, by calcination: which removed by hydrochloric acid, from the residuum of first calcination, *gave a distinct trace of platinum, as I considered it.*

"Perhaps I might have been mistaken. I was led to notice it, from the fact that platinum is found associated with chromite of iron in Siberia, as well as in the chromite of iron and iron sand of St Domingo. The Chester chromite of iron has been tested by the Messrs. Tieman of New York, practical chemists. When made fine and free from the matrix, silex, alumina and magnesia, as pure as usual for the arts in gross, it is found to yield, like the Maryland and Pennsylvania chrome ore, about 43 per cent. of protoxide of chrome, which combines with the potash."

It is well known that some of the most beautiful paints in use, as the chrome yellow, chrome green, &c. are prepared from this ore. And to such a use it is Dr. Holland's intention to apply the Chester chromite, whenever it can be done profitably. The foreign salts of chrome have till recently been sold at so low a rate, that it has been impossible to compete with them in a country where labor is so dear as among us. But these articles have recently risen in market: and it seems hardly possible to doubt, but that a mine of chromite of iron must ere many years become exceedingly valuable. A few years since, Dr. Holland prepared several salts from the Chester chromite, and he has been kind enough to send me the only parcels of them yet remaining, and I have put them into the collection forwarded herewith. No. 2498 is a specimen of the Chester chromite of iron: No. 221 chromate of potassa: No. 222 chromate of lead, or chrome yellow: No. 223 dichromate of lead.

I have recently subjected to analysis a specimon of the chromite of iron from Chester, presented to me by Dr. Holland; following the rules given by Dumas in his *Chemie applique aux arts, Tome Troisieme, p.* 446. 25 grains yielded as follows:

Mineral undissolved by the nitre and potassa,	1.80
Silica associated with the oxide of iron,	1.84
do. with the Chrome,	0.30
Alumina associated with the iron,	0.16
do. with the chrome,	1.10
Oxide of Chrome,	8.00
Per Oxide of Iron,	11.70
Loss,	0.10
	25.00

Exclusive of the silica and alumina, the chrome in the preceeding analysis amounts to about 40 per cent; agreeing, as I understand it, with the foregoing statement by Dr. Holland. But if the analysis be reduced to a centessimal standard, (neglecting the loss of the undecomposed residue,) it will stand as follows. I have added for the sake of comparison analyses of the chrome ore of St. Domingo and Baltimore.

	Chester, Mass.	St. Domingo.	Baltimore.
Oxide of Chrome,	34.63	36.0	39.514
Oxide of Iron,	50.65	37.0	36.004
Silica,	9.27	5.0	10.596
Alumina,	5.45	21.5	13.002

There is a good deal of diversity in the amount of ingredients in the chromite of iron from different localities. Dumas thinks they can all be reduced to two formulas: the first of which embraces the Chester Chromite:

$$Ch\,O + Fe^2\,O^3$$
$$3\,Ch\,O + Fe^2\,O^3$$

Beudant thinks it necessary to admit at least four different combinations of the ingredients. (*Traite de Mineralogie, Tome Second, p.* 666.)

Phosphate of Iron.

The earthy variety of this ore has been found, in considerable quantity, at the mineral spring in Hopkinton. It forms a bed, one or two feet below the surface, and has been employed as a pigment. It is said to exist also near Plymouth.

Sulphuret of Iron, or Iron Pyrites.

This is the yellow ore so frequently mistaken for gold. It occurs more or less in almost every rock; but it is of no use, unless it exists in large quantities, and is of that variety which easily decomposes. In such a case, it may be converted into the sulphate of iron; that is, into copperas. The ore is broken up, and exposed to the action of air and moisture, when the change takes place, and the lixivium is evaporated to obtain the copperas. In Massachusetts, one can hardly avoid meeting with iron pyrites; and in the western part of Worcester county, the traveller cannot but notice, that nearly all the rocks are coated over with iron rust. This is the result of the decomposition I have spoken of. In Hubbardston, the sulphate is so abundant, that a manufactory of copperas has been established, and I believe success has thus far attended the enterprize. The annual produce is about 75 tons. I should presume that copperas might be manufactured in several other towns south of Hubbardston; as in North Brookfield and Southbridge, although the rocks do not appear as highly impregnated with pyrites in any place as in Hubbardston.

The decomposition of pyrites, in large quantities, often produces a considerable degree of heat; and sometimes pieces of rocks are driven off with explosion. This is one of the sources of those numerous stories which one hears in the country, concerning noises heard, and lights with smoke seen in the mountains. Such occurrences excite the belief of the existence of valuable mines in the vicinity: but they evince the existence of nothing more than iron pyrites.

Magnetic oxide of Iron.

This is a valuable ore, affording from 50 to 90 per cent of iron. It exists in several places in Massachusetts, and on the borders of the State. When pure it contains about 69 per cent. of the peroxide and 31 per cent. of the protoxide of iron.

Hawley Iron Mine.

The principal ore here is the magnetic oxide, which is very good, and the bed is favorably situated for exploration. The ore does not seem to be abundant, the bed being rarely more than one or two feet wide. It has been wrought to some extent; but the operations are at present suspended. Micaceous oxide of iron occurs at the same bed.

The same bed of ore makes its appearance a mile or two south of the excavation: and also, as I have been told, two or three miles north, in Charlemont

Beds of Magnetic Iron ore in Chester.

In the western part of Chester, near the bed of serpentine and soapstone already described, not far from the Western Rail Road, are several beds of magnetic oxide of iron: none of which exceed a foot in width. They occur in the hornblende slate, a little east of the serpentine and soapstone, on the same high hill. Like them, the ore also extends southerly into the mountains towards Blanford. And by looking at the geological map, it will be seen that the talcose slate and hornblende slate formations of Chester extend northerly across the state; and embrace the Hawley iron ore: so that probably it will be found that this ore is common along the junction of these rocks. Indeed I have lately had intimation that in the south part of Hawley, the ore occurs in large quantity: but I have not since had an opportunity to visit the spot.

Vein of Magnetic Oxide on Beartown Mountain.

Mr. Daniel Couch of South Lee showed me a specimen of magnetic oxide of iron of good quality, which he obtained from a vein in quartz rock on Beartown Mountain, near the road to Beartown, and within the bounds of Tyringham. At the surface, the vein was only 4 inches wide: but on exploring it a few feet downwards, it had enlarged to 18 inches.

Bed in Bernardston.

In describing the bed of limestone in Bernardston, I have already spoken of the bed of magnetic oxide of iron, several feet thick, contained in the limestone; and of the attempt made some years ago to smelt it. Both beds dip at a moderate angle to the southeast, and are accessible without difficulty. Although the trials that were made with this ore, were not very successful, yet there can be but little doubt that those trials were very imperfect; and since the ore is abundant, it will no doubt ere long, attract the attention of those engaged in the manufacture of iron. A specimen analyzed (No. 505,) gave the following results:

Peroxide of Iron,	57.86
Protoxide of do.	25.98
Silica,	9.90
Magnesia,	5.42
Manganese,	0.54
Loss,	0.30
	100.00

This analysis shows no ingredient in this ore that would resist its reduction, except perhaps the small quantity of manganese; and to conquer this, nothing more is needed than the hot air blast, so commonly used in the country at this day for the reduction of iron.

Bed in Warwick.

Near the east line of Warwick, in a hill of mica slate, are at least two beds of magnetic oxide of iron, several feet in width: but as they have never been opened to any extent, their exact

width is difficult to be determined. There can be no doubt however, that the quantity of ore is amply sufficient for every purpose of the manufacturer. It is very compact; and has a specific gravity of 4.47. Hence it would probably require the mixture of some other kind of ore, in order to be readily reduced. It also contains manganese, which will make it desirable to use the hot air blast for smelting it. I cannot but believe that the want of these, or similar precautions, was the cause why an attempt to reduce this ore several years ago was unsuccessful. At least, the following analysis discovers no other cause for the failure.

Peroxide of Iron,	46.34
Protoxide of do.	20.70
Silica,	15.28
Manganese,	7.92
Magnesia,	4.18
Lime,	4.88
Loss,	0.70
	100.00

I feel confident that the preceding analysis, as well as that of the Bernardston ore, give the per cent. of iron very near the truth. But in regard to the other ingredients, I do not feel quite so sure; because I have not been able to make all the verifications that are desirable. As a ground for judging of the value of the ore by practical men, these results are doubtless sufficient: but for scientific deductions they ought to be repeated.

Magnetic Ore Beds on the borders of Massachusetts.

As much of the ore from these beds is used in Massachusetts, I ought to refer to them. In Winchester, N. Hampshire, a bed exists only two or three miles from Massachusetts, which was formerly worked: and the ore is said to be abundant: but I have not visited it. In Somerset, Vermont, several miles north of Massachusetts, is a rich deposit of this ore, which is very successfuly wrought, and forms beautiful iron. But the largest deposit of this ore is in Cumberland, Rhode Island, two miles northeast of the centre of the town, and of course almost on the line between the states. A large hill is here almost entirely composed of iron ore; and it exists in many other places in the town. I am not aware that this ore has been analyzed: but I apprehend that it will be found to be very much impregnated with manganese. A few years ago I was informed by General Leach of Easton, who then owned this hill, that it did not yield more than 25 to 30 per cent. of metallic iron.

Micaceous Specular Iron Ore, at Hawley.

I have met with the common specular iron ore scarcely any where in Massachusetts. At Malden it is said to exist in small quantity, in porphyry; and in Mendon in granite. And I have seen a specimen blasted from the rail road cut in sienite, in Dedham. Of the micaceous oxide of iron, however, which is a variety of the specular oxide, we have a fine locality in Hawley, where it is associated with the magnetic oxide already described. For cabinet specimens it is very fine, as a reference to No. 844, will show. Formerly this ore was rejected as of no value: though afterwards it was

smelted. And it is indeed an exceedingly pure ore, which must yield nearly 70 per cent. of iron; as the following analysis will show.

Peroxide of Iron,	99.26
Water, (lodged probably between the scales of the ore,)	0.60
Loss,	0.14
	100.00

We may safely consider this ore as an absolutely pure peroxide of iron: the oxygen amounting to 30.66 per cent. and the iron to 69. 34. Whether a large quantity of it can be obtained at the mine I could not accurately determine.

Micaceous Iron Ore in Montague.

Near the mouth of Miller's river is a hill of considerable extent, which appears to be traversed by numerous veins of this ore. The largest which comes in sight, is in the southeast part of the hill, at the top of a ledge of mica slate and granite, and is several feet in width. It is favorably situated for exploration, and unless the ore is injured by an occasional mixture of sulphuret of iron, I do not see why it might not be profitably wrought. Wood is very abundant in the vicinity, and it is not far from Connecticut river. Good micaceous oxide of iron, yields about 70 per cent. of excellent iron.

According to Professor Webster, thin veins of micaceous iron ore exist in the porphyry of Malden, which were formerly wrought to some extent. It occurs also in graywacke, at Brighton, and in greenstone at Charlestown, according to the Messrs. Danas.

Limonite, or Hydrated Peroxide of Iron.

In this species are embraced nearly all the iron ores that have been wrought in Massachusetts; viz. the Brown Hematite, the Argillaceous Oxide, and the Bog Ore, with red and yellow ochres.

Brown Hematite.

Connected with the limestone, mica slate, and talcose slate, along the western side of the Green Mountain range, in the eastern part of New York, and the western part of Connecticut, Massachusetts, and Vermont, are numerous and extensive beds of the brown hydrate of iron, commonly called *hematite.* This is a most valuable ore; and has been extensively explored in all the states above named; as at Kent and Salisbury in Connecticut, at Amenia, Beekman, Dover, Fiskill, &c. in New York; and at Bennington, Vermont. I am satisfied that the ore usually forms beds in mica slate. But most of those that have been explored are in diluvium; having been removed from their original position by diluvial or alluvial agency. In a few excavations, however, the ore is seen between the layers of the slate. This is a point of no small importance. For if the ore exists only in diluvium, it

may ere long be exhausted. But if the masses in diluvium be only the detritus of beds in the slate, there is scarcely any probability that the ore will ever be exhausted: since we may suppose that it extends as deep into the earth as the slate.

The brown hematite of Massachusetts is confined I believe to Berkshire County. The ore is sometimes fibrous and concretionary, (which are the purest varieties) but more commonly compact or vesicular, and often ochrey. I shall now give a brief account of those beds of this ore whose existence I have been able to ascertain in Berkshire.

To begin with the south part of the County. I have been informed that several hundred tons of this ore were dug some years ago in the south part of Tyringham, and that indications of extensive beds exist there. But I have not visited the spot.

In the west part of New Marlbourough, on the farm of Josiah Sheldon, several excavations have been made a few feet deep, over a space of several acres, and an abundance of yellow and light red ochres extracted; such as usually accompany beds of hematite. I can have little doubt that farther exploration would bring to light an extensive bed of ore.

In Great Barrington, a deposit of this ore exists at the south end of Long Pond, which was formerly wrought to some extent. Another deposit occurs about a mile and a half northeast from the village; and several others exist on the east side of the Housatonic farther south. There can be no doubt that the ore may be found in this town in abundance.

In Stockbridge there are indications of this ore a little distance north of the village, accompanied with much sulphuret of iron.

In Lenox, as many as four or five beds have formerly been opened, and much ore has been carried away. One excavation was made in the village, and several others a mile or two west of the village: so that we have every reason to suppose the soil to abound with the ore.

One deposit at least exists in Alford: but its extent is not known.

In Lee, are indications of several beds; as one can see in many places, where the earth has been excavated a few feet for highways.

A very large deposit has long been explored in West Stockbridge, from which, in 1837, no less than 4000 tons were extracted: which were valued at $2000: and probably this is not far from the average annual produce of the mine.

Judging from what is at present known, Richmond abounds in this ore more than any other town in the county. Not less than 12 beds are known: most of which have been more or less explored. At one of these beds, in the east part of the town, I noticed that the quantity of yellow ochre was very great. At another, in the southeast part of the town, I found the best specimens of the fibrous variety that I had seen in the county. The fibres are several inches long. As this is the purest variety of the brown hematite, I subjected it to analysis with the following results.

Peroxide of Iron,	85
Water,	14
Oxide of Manganese,	1
	100

In the northern parts of Berkshire, very few deposits of this ore have been explored. In Cheshire, some years ago, a bed was opened one mile west of the Common, which yielded considerable ore: but it is not now explored. Two or three miles northeast of the north village in

Adams, also, numerous rolled masses of this ore were shown me at the foot of Hoosac Mountain. Some of these pieces were more than a foot in diameter: and I was assured they might be found half way up the mountain. In short, the indications are very favorable of a large deposit in that place. In the south part of Williamstown, also, on land of Joshua Morey, the hematite appears in the banks of a small stream. But without exploration it is impossible to judge of its extent, or value. One mile east of this spot is a bed of yellow ochre, which was formerly explored.

For reducing the ores that have been described in Berkshire, I cannot ascertain that more than four furnaces are in operation. In 1837, according to the returns made to the Secretary of State, the following was the amount and the value of the iron reduced.

In Great Barrington,	One Furnace,	Pig Iron,	180	Tons,	Value	$ 7.200
In Lenox,	do	do	500	do	do	22.500
In Richmond,	do	do	600	do	do	26.400
In Stockbridge,	do	do	1337	do	do	53.480
						$ 109.580

It will be obvious from the above statement, that there are probably many deposits of hematite in Berkshire county yet untouched, that might easily be brought to light. And doubtless many others will from time to time be discovered when the attention of discerning men is more turned to the subject. In Richmond, the existence of one of the deposits that has since yielded abundantly, was first made known by the fragments thrown out of his hole by a woodchuck. And wherever the limestone is accompanied by mica slate, as it is through all the valleys of Berkshire, I can see no reason why we may not expect to find the ore, whenever man or beast shall penetrate the detritus that now conceals it.

Clay Iron Ore.

This is the hydrate of iron more or less mixed with clay. It embraces two varieties in Massachusetts, the nodular and pisiform, and the bog ore. The former is found only in the southeastern part of the state; where it is connected with a tertiary formation, which I have considered identical with the Plastic Clay of Europe. Its richest locality is at Gay Head, and its vicinity: where nodules occur, sometimes nearly a foot in diameter, of excellent ore. It occurs there also, with a pisiform structure; and also mamillary. Of the latter variety, the best locality is at Minimshi Bite, about three miles easterly from Gay Head. The ore is so abundant at these localities, and so good, that I am surprised it has been no more sought after. It was, however, used in furnaces on the continent during the last war. Nos. 119, to 123, will give a good idea of the varieties of this ore.

Bog Ore.

This variety of the argillaceous oxide, is more abundant than any other in the State, and has been used extensively in the manufacture of cast iron; for which it is chiefly adapted. In the following towns it is found in large quantities: viz. Groton, North, West, and South Brookfield, Carver, Hopkinton, Hardwick, New Braintree, Oakham, Berlin, Sturbridge, Southbridge, Freetown, Dartmouth, Rochester, Troy, Easton, and Sharon; and in the following, it exists in greater

or less quantities; in Middleborough, Malden, Seekonk, Sheffield, Templeton, Warwick, Williamstown, Greenfield, Northampton, Springfield, Williamsburg, Dalton, Holland, Wales, Norton, Mansfield, Bridgewater, Stoughton, Spencer, Gloucester, and on Martha's Vineyard: indeed, I can hardly doubt that more or less of this ore may be found in nearly every town in the State. I found it so common that at length I ceased to enquire for it, and the localities are so numerous that I have not attempted to exhibit them all upon the Map.

It ought to be recollected, that the process by which bog ore is deposited, is in many places now going on, particularly at the bottom of ponds. The interval between one dredging and another, was so variously stated to me, that I suspect it differs greatly in different places. I presume, however, that it ought never to be put less than twenty years. But the fact that there will be a renewal of the deposit after a certain time, is interesting: because it shows that this mineral will never be entirely exhausted.

2. *Lead.*

Several ores of this metal are enumerated by mineralogists, as occurring in Massachusetts; but none is found in sufficient quantity to render it of any statistical interest except the sulphuret, commonly called *galena*: and the most important veins of this species are confined to the vicinity of Connecticut river. No fewer than fourteen of these occur in that region of sufficient importance to deserve notice. All these are in mica slate or granite; or they pass from the one rock into the other.

In Southampton.

The vein in the northern part of this town has attracted more attention than any other in the region, and has been several times described. It is six or eight feet wide where it has been explored, and traverses granite and mica slate, the matrix or gangue containing the ore, being a mixture of quartz and sulphate of baryta. It has been opened forty or fifty feet deep, in several places, and masses of ore were dug out from half an inch to a foot in diameter. As the vein descends almost perpendicularly into the rock, water soon accumulated in such quantities, as induced the proprietors to attempt reaching the vein by a horizontal drift or adit, from the bottom of the hill on the east side. This was no small undertaking, as the opening must be carried nearly a quarter of a mile into the solid rock. It was persevered in, however, at a great expense, for a distance of nearly nine hundred feet, when one of the principal miners having died, and the price of lead having fallen two or three hundred per cent. all operations were suspended, and I believe the proprietors wish to dispose of the mine. Had they continued this drift a few feet farther, there is every probability that the principal vein would have been struck, from one hundred and fifty to two hundred feet below the surface. Perhaps, however, the work cannot be successfully and profitably resumed

until the market shall cease to be glutted with lead from Missouri; but there can be little doubt, that immense quantities of ore may be obtained at this spot, it may then probably be explored with advantage. I do not doubt, however that those who first examined this mine were mistaken in the opinion that this vein extends from Montgomery to Hatfield, a distance of twenty miles. Lead may indeed be found at intervals along a line connecting those places. But I have every reason to suppose, that it proceeds from several distinct and independent veins.

The principal ore above described is the sulphuret; but there have been found here also, the carbonate, sulphate, molybdate, muriate and phosphate of lead, along with the sulphuret of zinc, pyritous copper, and fluor spar. Mineralogists will greatly regret, that mining operations have been suspended here, because they were anticipating the development of rich specimens of these and other minerals.

Another vein of galena exists in the south part of Southampton, near the line of Montgomery. It appears for several rods on the surface, but is only a foot or two in breadth. A few years ago, efforts were made to open this vein by a horizontal adit, but the proprietors became discouraged and abandoned the undertaking.

In Northampton.

This vein is only a short distance north of the principal vein in Southampton above described. The gangue is radiated quartz, and the walls are mica slate. Yellow blende or sulphuret of zinc abounds here: and the vein was formerly explored to a considerable depth. It is several feet wide.

In Westhampton.

This vein has been usually described as existing in Williamsburg and extending into Northampton. But so far as it exhibits itself at the surface, it lies wholly in Westhampton—in quite the northeast part of the town, only a few rods from the Northampton line, and but half a mile from that of Williamsburg. The gangue is quartz, and the vein is several feet wide, and may be traced 30 or 40 rods. But the quantity of galena is small at the surface.

In Williamsburgh.

A vein of galena lies in the northeastern part of this town, and probably extends into Whately. It is two or three feet wide, and the gangue, as in nearly every other vein of lead in this region, is quartz. Manganese is found in the same gangue.

A second vein of quartz with galena occurs in this town, a mile or two northeast of the one last mentioned. The quartz, however, appears only in loose masses on the surface, but to such an extent, as can be explained only on the supposition, that a vein exists in the rock beneath the soil. Pyritous copper is found in connection with the galena at this place.

In Goshen.

According to the statements of Mr. Alanson Nash, who has given a map and description of the lead veins and mines of Hampshire county, in the twelfth volume of the American Journal of Science, the same indications of a galena vein appear a little west of the centre of Goshen, as those mentioned in respect to the third vein in Williamsburgh just noticed, viz. the occurrence of masses of quartz containing galena. The rock in the region is mica slate and granite.

In Whately.

In this town are three distinct veins containing lead. One is about half a mile east of the first vein described in Williamsburgh It extends a short distance into Whately. In its whole course, but particularly at its southern part, it contains oxide of manganese along with galena.

A second vein, three or four feet wide, exists in a high ridge of granite towards the southwest part of the town. It may be traced along this ridge about three quarters of a mile.

The third vein is in the northwest part of the town, extending some distance into Conway. Galena, in quartz, is the only ore that appears on the surface. The width of the vein is six or seven feet, and it traverses both granite and mica slate. It runs along the western margin of a high hill, so that if it should ever be explored, a lateral drift could be easily made.

In Hatfield.

About two miles west of the village in this town, we find a vein of sulphate of baryta, from one to four feet wide at the surface, running in a northwesterly and southeasterly direction and containing galena. A shaft has been sunk in two places from fifteen to twenty feet deep: and the vein was found rapidly to widen in descending. The immense quantity of baryta found here, gives the locality a peculiar interest to the mineralogist.

In Russell.

On the hill southwest of Westfield river near Gould's mills in Russell, is a vein of quartz from 2 to 4 feet thick, traversing the granite and mica slate,

and containing galena, blende, and copper pyrites. At the surface the ore is rather sparingly disseminated through the rock. The vein runs nearly north and south, and descends into the hill perpendicularly. The spot where it appears is from 200 to 300 feet above the river, and favorably situated for mining operations should it be thought desirable to undertake them.

In Leverett.

Although this town lies on the eastern side of Connecticut river, yet the granite and mica slate, occurring there, exactly resemble the same rocks found on the west side of the river; and there can be no doubt that both belong to the same general formation. Two veins, the ore being chiefly galena, are found of precisely the same character as those on the opposite side of the river. That in the southwest part of the town is in granite, not more than a foot or two wide at the surface, and the gangue is sulphate of baryta. The other is a mile and a half to the north of the first: the gangue is quartz, and there is almost an equal quantity of galena and pyritous copper; blende also occurs in small quantities. This vein is several feet wide, and runs through granite and mica slate. Both this and the one first mentioned, have been explored to the depth of a few feet.

It is impossible to form any confident opinion as to the probable quantity of lead, which is contained in the several veins which have been described, except, perhaps, in regard to that in Southampton, which has been explored to a considerable extent and is probably the master vein. In many instances appearances at the surface are quite favorable; but whether the veins become wider, like that in Hatfield, or narrower as they descend, can be determined only by actual exploration. Of one thing, however, I think we may be assured, from the facts that have been stated; viz. that the central parts of Hampshire county contain extensive deposits of lead, which may be of great value to posterity, if not to the present generation. Probably many more veins will hereafter be discovered, since little examination has been made with a view to bring them to light.

In Alford.

On mile north of the centre of Alford is a vein of quartz, several feet wide, traversing limestone, and containing galena and iron pyrites. The vein is not very well defined, and being also much hid by soil, I cannot speak with much confidence as to its actual width. The formation is obviously of the same character as that containing numerous veins of galena in Columbia and Duchess Counties in New York. Prof. Mather states that most of these are situated near the junction of limestone and slate rocks. Slate rock is near the vein in Alford. The only vein in New York that has been extensively wrought, is the Livingston mine in Ancram. This is said to be highly argentiferous, producing 118 ounces of silver to the ton. (*Second Report of the New York Geologists for* 1837 *p.* 176.) I have made no trial of that from Alford to ascertain this point.

In Uxbridge.

On land of Chilon Tucker, in the south part of Uxbridge, galena in small quantity is found in quartz rock: but whether it constitutes a distinct vein, or is disseminated through the rock, I could not certainly determine. The quanity at the surface is small, and the appearances do not indicate a large deposit. The rock, which is stratified, runs N. E. and S. W. and dips 25° S. E. It has been blasted only a few feet in depth. This ore is highly argentiferous, and on this account may deserve attention.

In Dedham.

In the south part of Dedham bowlders of quartz containing galena, occur in considerable quantity: 100 pounds or more of the gangue have been obtained. These facts I state on the authority of William Ellis, Esq. of Dedham who gave me specimens of the ore. But I was disappointed in my intention of visiting the spot, and can add nothing more.

3. *Copper.*

This valuable metal occurs in numerous places near the junction of the greenstone and sandstone, in the valley of the Connecticut, between New Haven and Vermont. Several veins of copper ore are found in Connecticut; near the junction of the two rocks, and two of these have been explored extensively: viz. one in Cheshire, which gives much promise, and another in Granby. The latter has long been known under the name of Simsbury mines, although it is within the limits of Granby. Many years ago, before the war of the revolution, I believe, this vein was explored to a considerable extent. Afterwards the government of Connecticut made use of the abandoned shafts and galleries for a State Prison. Since the removal of this prison to Wethersfield, the exploration has been resumed, by a new company, and, as I am informed by the agent, with success. The principal part of the ore, according to Prof. Shepard, is the vitreous copper, associated, however, with green carbonate and variegated copper.

In Greenfield.

In the northeastern part of this town, on the banks of Connecticut river, are two veins of copper ore about a mile apart: the most northern one being about one hundred rods below the mouth of a small stream, called Fall River, and the same distance in a direct line form the cataract in Connecticut river, sometimes called Miller's Falls; but lately, and more appropriately, Turner's Falls. These veins are several feet in width, and they pass into a hill of greenstone on one hand, and under the river on the other into sandstone. The gangue is sulphate of baryta and toadstone, and the

ores are the green carbonate of, and pyritous copper. Actual exploration alone can determine whether these veins might be profitably worked.

On the most southern of the small islands, in the middle of Turner's Falls, has been found a vein of pyritous copper, of a rich quality, and in considerable quantity. Indeed, several varieties of the sandstone rocks in the vicinity, appear to be considerably impregnated with copper.

Pyritous copper is associated with iron, in a vein, in greenstone, at Woburn; but not, probably in a sufficient quantity, to be worth mining. At several places in Cumberland, R. I., where excavations were formerly made, are found gray oxide of copper and pyritous copper with the green and blue carbonates.

4. *Zinc.*

The sulphuret of this metal exists in considerable quantity in some of the veins of galena that have been described in Hampshire county. In a vein especially, a mile northeast of that in Southampton, which has been so extensively explored, blende appears to be the principal ore. This spot has been dug several feet in depth, and a good deal of rubbish thrown out along with good specimens of zinc. But I believe this ore was not used.

In Norwich.

About a mile northeast of the meeting house, near the center of Norwich, Quartus Angell has opened a vein of quartz containing blende in coarse decomposing granite. The specimens of quartz are sometimes elegant; but I noticed no other ore at this spot except the zinc. The exploration was several feet in width and depth; but being partially filled with rubbish, I could not ascertain the width of the vein. I presume it will be found to contain some galena, though I saw none.

Cadmia.

A deposit forms in the chimneys of the iron furnaces in Berkshire county (I noticed it particularly at Richmond and Van Deusenville,) several inches thick, which analysis shows to be almost pure zinc. This must exist in the iron ore, and be sublimed by the heat. No use, as I could learn, has hitherto been made of this substance, which has received the name of *cadmia*. But it would certainly answer an excellent purpose in the manufacture of brass.

5. *Manganese.*

In a metallic state this mineral is of no use; and indeed, it is reduced to that state with great difficulty. But in the state of oxide, it is extensively employed, both to remove color from glass and to impart colors; also in painting porcelain and glazing pottery, and still more extensively within a few years, in the manufacture of the chloride of lime, now so generally used in bleaching.

At least two ores of manganese abound in the western part of Massachu-

setts. It has been already remarked, that more or less of the gray oxide exists in the iron beds of Berkshire, and Bennington, Vt. In the vicinity of Connecticut river, however, or rather on the eastern slope of Hoosac mountain, distinct veins and beds of manganese are found.

In Plainfield.

Beds of the oxide of manganese occur in two places in this town, one a mile west of the center, and the other near the southwest corner of the town; and both in talcose slate. Two ores are associated at both these places, viz. the common gray or black oxide and the silicate; the former investing the latter as a black crust, and most probably proceeding from its decomposition; while the latter, when newly broken, is of a delicate rose red. I suspect that the silicate predominates at these places; and from these beds, probably came by diluvial action, those numerous rounded masses of the same in the vicinity of Cummington meetinghouse; although a deep valley intervenes, and the distance is three or four miles.

An attempt was made, some years ago, to explore one of these beds, under the impression that the ore was iron. But how extensive either of them is, it is difficult to determine, as each seems to consist of a number of small beds, or rather the ore is interlaminated with the slate. The occurrence of so much siliceous oxide at these localities, is very interesting to the mineralogist, because this ore is rare in Europe.

In Conway.

A distinct vein of the black oxide of manganese several feet wide occurs in the southeast part of this town, the gangue being quartz. It has not been explored at all; nor is the manganese ore very abundant at the surface. I do not doubt, however, that it may be found here in large quantities.

6. *Tin.*

I am able to say with perfect confidence that this interesting metal exists in Massachusetts: but can add little more. I found only a single crystal of its oxide, weighing 50 grains. But this I dug myself from a block of granite in the northwest part of Goshen, and on reducing it to metallic tin, it corresponds exactly in every respect with that metal from England. I have never been able to find any more specimens; but it ought to be borne in mind, that in England, according to a geological writer of that country, "it is generally in the vicinity of a vein of tin ore, that disseminated grains of tinstone are found in the rock."

Mohs, in his Mineralogy, mentions that some small crystals of tin were found in specimens sent to Europe from Chesterfield, Mass., and Prof. Shepard informs me that he has found small crystals in the green feldspar rock of Beverly; and also in the granite of Connecticut.

7. *Silver.*

No silver has yet been found in the state, except the small quantity that is usually contained in lead ore. In the galena at Southampton it occurs in the proportion of about 12 1-2 ounces to the ton: a quantity hardly worth the labor of separating. As already stated it exists also in the galena of Uxbridge. The ore from other localities I have not examined for want of time.

Misguided Efforts after Gold and Silver.

Were the history of the wild and ill-directed efforts that have been made, even in Massachusetts, in search of the precious metals, to be written, it would furnish at least important warning to others; and therefore I shall state a few facts on the subject.

The large quantities of the precious metals carried to Europe from South America, soon after its discovery, naturally produced some expectation of finding similar treasures here. But I cannot learn that our forefathers expended large sums in making excavations, where there was no reasonable prospect of finding anything valuable. It was reserved for their descendants to exhibit a credulity and superstitious ignorance on the subject, that are both lamentable and ridiculous.

Perhaps at the present day, a belief in the mysterious virtues of the mineral rod, is the most common of these delusions. Probably many of our intelligent citizens can hardly credit the statement, that there are men in various parts of the State, who profess not a little skill in this enchantment, and are not unfrequently sent for, one or two day's journey, to decide whether there be ore or springs of water in a particular place. In general, but not always, these professors of divination belong to the most ignorant classes in society; for not long since, a venerable and respectable man of good education, sincerely thought it his duty, occasionally to peregrinate with his divining rod, because *it would work in his hands;* and not a few intelligent men have a secret belief, that the branches of a witch hazel are attracted downward towards mineral substances, when in the hands of a certain individual.

The following train of circumstances often takes place. A man, ignorant of mineralogy, finds upon his farm, a specimen of iron pyrites, or yellow mica, or galena, which he mistakes for gold or silver. Even if he shows it to a mineralogist, and is told that he is mistaken, he suspects that his informant is deceiving him, in the hope of getting possession of the prize himself.

spot to form a company and commence digging. They sunk a shaft to the depth of between 70 and 80 feet, the greater part of which was in a solid rock: and found nothing except a few fragments of a cubical form, resembling gold in appearance, which would burn on being placed in hot coals. Iron pyrites is now found in the same rock, where they are digging for coal.

"After spending an immense sum, all gave up their operations for the want of funds, save the owner of the farm, who being more and more confident from day to day that a great treasure was there, continued to excavate till he had run out his farm and was obliged to sell. He, like the Alchemists, had millions almost in his possession: yet was compelled to sell all he had, to buy a little bread to keep himself and family from starving.

"The farm was sold to Mr. Abijah White, whose son lives upon it now: and in deeding away the place, Mr. Wellman, reserved the privilege, for his posterity, at any time when they should become able, to dig for gold or silver any where upon the place. And within the last four years, one of the grandchildren, Joseph Wellman, came to Mr. Howard Mann, to let himself by the month to dig for gold, promising that Mr. Mann should have a certain part of all that was found. About that time I visited the spot, at Mr. Mann's request, and the conclusion to which we came was, that it was a coal region, and that it might be an object to dig for coal. Mr. Mann then made an agreement with Wellman to dig by the month; but just as he was about to commence, he was taken sick and has done nothing about it since. But I presume he would not sell his right to dig on that farm for half its value.

"The other case of which I gave you an account, was in Dedham, on a farm owned by Mr. Rhodes. In this case they were after Capt. Kidd's money. It seems that in some way or other it was ascertained that there was a large amount of his money there, and a company was formed to dig for it, who sent a committee to make a bargain with Mr. Rhodes the owner of the land for the right to do it.

"Their instructions were to make an agreement, cost what it might They at length proposed to fill Mr. R's grist-mill trough with dollars, (the trough was reported to hold four or five bushels,) for his proportion. Mr. R. declined taking it, preferring rather to have his share of what they found. Upon this they continued to dig in various places on the farm for several months, until the whole Company had spent their property, when they finally gave up the search; and Mr. R. from a comfortable farmer miller, became a poor man.

"This account I had from Mr. Eliphalet Rhodes, a grandson of the owner of the place: and he states these facts to have occurred upwards of 75 years ago.

"At this enlightened age, one would suppose that such ridiculous notions would be given up: but within the last four months, a young man belonging to this town, has secretly commenced digging for the precious mineral. He succeeded in finding the largest quartz crystals which I have ever seen. One of them, I should judge, would measure about 12 inches in circumference. When I stated to him that they were of little pecuniary value, and yet manifested a desire to obtain one of them, his suspicions were excited that I was deceiving him, and that they were ominous of golden treasures at the place. I tried to persuade him to relinquish his design. But this only made him more confident of success, and if I am correctly informed, he went directly to Boston for *disinterested advice*. He has not however resumed the exploration since his return."

I have given these rather mortifying details, partly because I doubt whether one tenth of our population are aware of the existence of such opinions and practices among us; and partly in the hope that the exposition may be instrumental in entirely eradicating them from the minds of those who have been thus deluded. For, like night fogs, they need only to be brought into the light of day to be dissipated.

5. SUBSTANCES USEFUL FOR VARIOUS PURPOSES.

A variety of mineral substances, too miscellaneous in their characters and application to be very systematically arranged, will be described under this general title.

1. *Materials for Roads.*

A good roadstone should be both hard and tough. Hence a large portion of the state is destitute of such material: for these two qualities are rarely combined in granite, gneiss, mica slate, limestone, or common sandstone. Sienite, which contains a good deal of hornblende, is better: porphyry, and especially compact feldsdar, is very good: as is also that hard quartzose slate which is associated with graywacke. This last is a good deal employed upon the roads around Boston; but must be limited to that vicinity, since it does not occur in other parts of the state, not even in the extensive deposit of graywacke in Bristol and Norfolk Counties. Upon the whole, probably greenstone is the best material for roads in the state; especially when we consider that it is very widely diffused. Around Boston, and in Essex county, as well as in some parts of Norfolk, it is common: and it is scattered more or less over a large part of Worcester county, in bowlders proceeding from numerous limited deposits: though this rock is usually confounded with fragments of dark colored gneiss; especially when the two rocks are coated with lichens. In the valley of Connecticut river, a range of greenstone, admirably adapted for a roadstone, extends nearly across the whole state. In Berkshire county, several varieties of quartz rock will probably serve as a good substitute for greenstone; though I am not aware that hitherto any of the roads there have been dressed with this material, except as nature has dressed them, in the form of pebbles:—a kind of dressing with which the traveller would very gladly dispense. The same is true in most other parts of the state: that is, the roads have not been coated with rocks pounded into fragments. But as more cost and labor are devoted to the roads, this will undoubtedly be done; and it is desirable to know where are the best materials.

In the bed and on the banks of the Merrimac, from Chelmsford to Newbury, is a hard slate approaching quartz rock, which I apprehend will answer nearly as well for a road stone as the slate around Boston associated with the graywacke.

At present, in the interior of the state, roads are usually improved by spreading over them some material already in a finely divided state, which shall form a harder basis, when trodden down, than the soil through which the road passes. The material must of course vary with the nature of the road. Clayey roads, for example, are very much improved by a coating of fine gravel; and sandy roads, by a coating of clay. In the vicinity of Connecticut river, the decomposition of the red slaty sandstone, and especially the calcareous diluvium, in Springfield and West Springfield, form an excellent covering for roads that are too sandy. The iron and calcareous matter cause the argillaceous matter to become hard, especially in the summer, and the track is often made as smooth as a rail road. Could such a material be discovered in the southeastern part of the state, it would be a great acquisition there for improving the roads, which are so sandy. Especially would it be desirable that the principal road from Plymouth to Barnstable now the most tedious in the state, should be thus improved. Might not clay enough be found at the cliff forming the north end of Manomet Hill, for at least a part of the work?

2. *Firestone.*

Whenever it is desireable to construct a furnace for smelting metals, burning limestone, and the like, it becomes an important enquiry whether a rock can be found in the vicinity that will bear

powerful and long continued heat. Such rocks are called *firestones:* and I have sought anxiously to find them in Massachusetts; not I trust without some success. But in respect to some of the localities, as they have not hitherto been known, no trial of importance has been made of the power of the stones which they produce to resist heat. I infer them to be firestones from their external characters—that is, their resemblance to real firestones.

A good firestone requires a union of qualities which is not very common. To answer well for a furnace, a rock must not only be infusible, but not liable to crack and exfoliate. Hence the presence of lime and magnesia, except as silicates, is unfavorable; and although pure quartz resists fusion well, it is liable to crack. On the other hand, some stones contain so much of potassa, or other easily fusible mineral, that they are converted into glass. The rock that has been most extensively used in the furnaces of Berkshire, and with most success, is a finely granular quartz, in which a small quantity of mica exists in layers. Its coherence is rather feeble. It is found in great quantities in the towns of Washington and Tyringham. (No. 2010.)

The talcose slate of the Taconic range of mountains has sometimes been employed for the lining of furnaces: as at Van Deusenville; and it will probably answer a good purpose. Some varieties of gneiss, that abound in arenaceous quartz, as at Southbridge, are used where strong heat is to be withstood. The micaceous sandstones are also employed for the same purpose; and the red sandstone in the vicinity of Connecticut river appears to be a very good firestone: as has been shown at the lime kiln in Whately.

A beautiful variety of mica slate, in which the layers of quartz and mica are of extreme thinness, occurs in Stafford in Connecticut: and enjoys a higher reputation than any rock in New England as a fire stone. I have lately succeeded in detecting this range of slate across the whole of Massachusetts; and have felt authorized in representing it on the map as continuous; although I have found it in place only at intervals. With the exception of some loose fragments in the west part of Monson, the first point where it appears in place, is on the north shore of Chicopee river, in Palmer, near the rail road, and about 100 rods east of Sedgwick's tavern. The road from Worcester to Springfield, passes close by a ledge on its south side, which there forms a hill 200 feet high. The greater part of this rock is probably too quartzose for firestone: but I doubt not that some of it in the hill would answer well. About three or four miles farther north than this spot, and a mile west of Palmer center, this slate shows itself: but there it is the common mica slate. The next point in proceeding northerly, where we meet with this range, is in Enfield. The high hill a little southwest of the village is composed of it. On its west side, whence stones have been obtained for building one or two factories, the rock is made up mostly of a dark gray arenaceous quartz, with mica sparingly interspersed. (No. 2078.) Some of this rock would probably stand fire well. But upon the top of the hill, extensive ledges appear, of a mica slate very much resembling the firestone from Stafford. (Compare No. 818 with Nos. 2071, 2072, 2073.) It is my belief that excellent firestone may be found in this hill: although some of the rock contains rather too much quartz. But the deposit is very extensive; reaching two miles at least south

of the village. It certainly deserves a fair trial, which it has never had. Nor can it be supposed that I should be able to find, in an examination of an hour or two, where only now and then a ledge appears, the specimens best adapted to the purpose of firestone.

The next spot north of Enfield, where I have found this range of slate, is in the east, and especially the northeast part of Wendell. But I have not carefully examined the intervening distance. In Wendell I saw none but the dark variety of the slate, some of which, however, is very arenaceous. But after passing Miller's river, in the direction of Warwick, the white variety appears in great quantity: and continues at least as far as the middle of Warwick, beyond which point I have not attempted to trace it. At Warwick the range passes about 100 rods east of the centre of the place, and may be traced easily all the way from thence to Orange. Upon the whole, I cannot doubt that this range will furnish, at no distant period, an abundance of excellent fire stone. But numerous trials will be necessary to ascertain the best varieties. I cannot hope to do more than to call the attention of those concerned to the localities.

There is one other locality of firestone in Massachusetts, viz. in Bellingham, which will be more particularly described in the next section.

3. *Whetstones and Grindstones.*

The whetstones that have been dug in Massachusetts have all been obtained from an arenaceous variety of mica slate: at least, all the quarries that have fallen under my notice were in rock of that character. Such is the rock in the northwest part of Norwich, where formerly a good many whetstones were manufactured. From the firestone deposit in Enfield, already described, a considerable amount of these stones have been for a long time annually wrought. Smithfield, in Rhode Island, has long been well known for producing whetstones: and they are obtained from a rock which I formerly mistook for talcose slate; but I am now satisfied that it is a delicate mica slate. The stratum of rock which produces them, extends northerly into Bellingham in Massachusetts; and in the northeast part of that town, on the farm of David Adams, it is so well developed, that it has been extensively quarried for whetstones. These are not considered equal to those from Smithfield; yet they answer well for sharpening shoe knives; and in 1838, not less than 22 800 were got out. The scales of mica in this rock, (Nos. 2104 to 2110,) are so fine as scarcely to be visible without a glass, and the rock might be mistaken for argillaceous slate. In Rhode Island it has been employed as a lining for furnaces; and that in Bellingham will undoubtedly answer well for the same purpose.

The only rock in the state which will answer much purpose for grindstones, is the sandstone in the valley of Connecticut river. As yet however, it has scarcely been applied to this purpose; though I have sometimes seen a rather coarse red variety, such as is got out at Hoyt's quarry in Deerfield, used in this manner. If not too liable to disintegration, I should suppose the red stone, composed entirely of grains of siliceous sand, quarried in Longmeadow, would answer well, where it is desirable to wear steel away rapidly. I shall mention only two localities where I suspect a good light gray stone for this use may be found. One is in the north part of South Hadley, near the Artesian Well, (at Hale's Mill) and the other on the north bank of Agawam river, a little

west of the village of West Springfield: (No. 171.) These rocks a good deal resemble the grindstones brought from Nova Scotia: yet where they have been long exposed to the weather, they are harder than the Nova Scotia rocks. But it ought to be recollected, that rocks are usually much harder at the surface than a little distance beneath it.

4. *Flagstones.*

Three things are important to form good flagstones: first that the rock should split into thin layers: secondly, that these layers should be even and smooth without hammering: and thirdly that its texture should be close, so as to resist atmospheric influences. Hence, first rate flagstones are not common. In Massachusetts quarries of this kind have been seldom sought after: as the demand has not been great in those parts of the state where they are most likely to be found. I shall mention only a few quarries that have been opened, and a few spots where I suspect they might be opened with advantage.

The most perfect flagstone that I have seen in the state is a variety of quartz rock in Berkshire County. Its principal quarry is in Washington, five miles southeast of Pittsfield. Large slabs can be split out, whose surface is perfectly even, and as smooth as if wrought with the utmost care. This rock occurs also in Tyringham, Lee, and other places.

The mica slate and talcose slate of the mountainous region lying west of Connecticut river, might furnish a large amount of excellent flagstones: as is evident from the numerous fine slabs which the traveller sees, forming the doorstones, and hearths of the farmer's houses in that region. Some quarries have been opened, as in the west part of Goshen, where the stone is fine enough to be employed without hammering for hearth stones. The mica slate, talcose slate, and hornblende slate, along the Western Rail Road, in the west part of Chester and Middlefield, appear to me to promise fine flagstones, if explored. But hitherto they have been neglected; as they have been indeed, over the whole extent of these formations, on account of the distance of a market. Whether the rail road will open a market for this article, I am incompetent to decide.

Another point on this rail road, but east of Springfield, where it seems to me good flagstones might be procured, is in the south part of Palmer, at the locality already described in speaking of firestone, 100 rods east of Sedgwick's tavern. The rock in that hill appears as if it would split with great facility into thin and even layers. And I should not be surprised, if some one should find a quarry there a valuable speculation.

The sandstone of the valley of the Connecticut furnishes some good flagstones. Three miles above Turner's Falls in Gill, at a spot called the Horse Race, very large slabs of a gray micaceous sandstone, have been got out, that would answer admirably well. At a quarry, already described, in the southwest part of Montague, near the banks of the Connecticut, the red micaceous sandstone often forms a beautiful flagstone; and probably vast quantities could there be obtained. Another quarry on the west bank of the same river, whence a considerable quantity of flags are obtained, and carried to Northampton, is in the southeast part of that town, on the east side of Mount Tom. The quantity easily accessible here is immense: but the quality is not very good. And it is a curious fact, that many of the surfaces are almost ruined by the tracks of large animals: as may be seen on much of the flagging in Northampton. This will probably seem fabulous to those who have never seen this phenomenon: but it is most assuredly sober fact.

5. *Fluxes.*

It is well known that in order successfully to reduce most ores, it is necessary to mix with them other substances, that melt more easily than the ore: and these are called a flux. Besides common clay, I scarcely know of any flux in Massachusetts, that need be noticed; except that

very valuable one, limestone. And I mention that here, merely to refer to one circumstance of considerable importance, that is undoubtedly now overlooked in this state. Limestone containing a large proportion of magnesia, is far less fit for this purpose than that which is a pure carbonate of lime. But since no effort has hitherto been made to distinguish between these two kinds of stone, the proprietors of furnaces probably use them indiscrimately. The circumstance is certainly deserving of their attention, since they can without difficulty obtain in Berkshire a flux of the best kind.

6. *Clay in the Manufacture of Alum, Fire Bricks, &c. and as a Substitute for Fuller's Earth.*

The white clay of Martha's Vineyard, described on a preceeding page, has been somewhat extensively employed on the continent, in the manufacture of alum—of which alumina forms the basis; and for fire bricks, pipes, &c. And since that is the only deposit of this kind of clay known in New England, it can hardly be doubted but the demand for it will increase.

In my former Reports I mentioned the fact, that the common clay of the Connecticut valley had been used as a substitute for Fuller's Earth. But I was not till recently aware how extensively this substitution had been made. I am told by the Agent of the Woolen Factory in Northampton, that this substitution is made very extensively in this state and in Connecticut, and that the clay is considered even better than the Fuller's Earth for cleansing the dye-stuff from cloth. That in Northampton has been considered as rather better than in other places: and hence it is transported often quite a distance. It is also used in private families for extracting grease and oil from cloth. It is first made into a paste, and then applied and suffered to dry. It doubtless operates by its great absorbing power. When applied to the tongue it adheres very firmly. No. 2502 is a specimen from Northampton.

I learn that the clay in the north part of Worcester County is employed in the same manner: and I doubt not but the variety proper for this use may be found in many parts of the state; although that in the valley of the Connecticut appears to be rather better than any that I have met with elsewhere. Fuller's earth, which is brought from England, sells, I am told, for $10 per ton The clay can cost nothing but the transportation.

8. *Moulding Sand.*

To say nothing of brass, no less than 76 furnaces are in operation in Massachusetts for casting iron; and these in 1836-7 produced articles to the value of $1,205,840. Yet most of the sand for making the moulds to these articles, is obtained out of New England. It hence becomes an object of importance to discover such sand in the state. But the late period at which my attention was called to the subject, has prevented me from that thorough prosecution of it which would be desirable. And further, I find that sand of so many sorts is employed for this purpose, that I hardly know what is essential in it. It should obviously be quite infusible; and therefore must not contain much common clay; which fuses too easily on account of the oxide of iron in it. Yet silica alone will not answer, because it has not adhesiveness enough to form and preserve the mould. The white clays that are destitute of iron, when mixed with sand, form a good article for casting bells and cannon. (No. 212 *b* from New Jersey.) Hence I suspect there is a substance at Gay Head (No. 211*b*.) composed of white clay and sand, and which may be obtained there in great quantity, that would answer. This substance is quite heavy; which is another circumstance of importance: and no gas will be produced from it when heated; an occurrence that would ruin the castings. I am informed by A. A. Hayes Esq. of Roxbury, that the

substance which I have described under the name of ***muck sand***, and which is often called quicksand, is employed by the brass founders in that place; and that it makes a sharp impression. The same substance is employed in Carver, as I am informed by John Savery Esq. for parting the moulds of castings and for the case of tea kettle spouts. Capt. Lemuel Drake of Easton, who has charge of extensive castings in iron, informs me, that he has obtained moulding sand, though not of the best quality, in Bridgwater, Medfield, Easton, and Foxborough. No. 166 is a specimen from the last named place; and No. 167 is from Montague: which I have placed in the collection, because it bears a resemblance to good moulding sand; although it has not been thoroughly tried. It occurs on the farm of Noah Goss, near the bridge over Connecticut river.

No. 168 is from the locality of blende and white clay in Norwich, already described; and may perhaps answer for moulding sand, as it contains no iron. The moulding sand used at the iron furnaces in Berkshire, is usually brought from Albany. It is said that a similar sand occurs in the north part of Lenox; and they bring from Lenox Mountain, decomposed mica slate to form the floor on which the melted iron is suffered to run out. I should think it strange if the decomposition of the talcose rocks on the Taconic mountain range, should not furnish some good material for moulding. In the valley of Connecticut river, also, I presume that the decomposition of the red sandstone must produce some fine sand of this description. Indeed, a fine red sand of this sort, is obtained from some town in Connecticut in that valley, which answers extremely well for castings in brass. (No. 215 *b*.) A large part of the moulding sand used for iron castings in this state, is brought from the vicinity of Albany. (No. 213 *b*.) I suspect that a similar article may be found in connection with the red and yellow ochres in the west part of New Marlborough, of which Nos 164 *b* and 165*b* present specimens. I would also suggest, that the peculiar reddish soil, which results from the decomposition of a reddish limestone in Stockbridge, and at the Tunnel in Saddle Mountain, will probably answer for moulding sand, when it is destitute of carbonate of lime (No. 192*b*). I should think this variety might be found near the upper part of the Tunnel above mentioned.

9. *Ochres and Stone Paints.*

It is well known that the oxide of iron, mixed with clay or soil, forms the paints called ochre. Although very many places in our soils have an ochery appearance, yet I have not till recently met with any deposits in Massachusetts that appear to me to promise much for paints. Those, of which specimens will now be found in the State collection, seem to me worthy the attention of those who prepare colors.

The deposit which promises far more than any other that I have seen, accidentally arrested my attention, as I was passing the farm of Josiah Sheldon in the west part of New Marlborough. In several places over a hill embracing a number of acres, he has made excavations a few feet deep, and found an abundance of yellow and light-red ochres, (see Nos. 164*b*, 165*b*,) which probably might yield some of the best of this sort of paints. And besides, it seems very probable, that there will be found in this field, a rich bed of the hydrate of iron, ore the hematitic iron ore, so abundant in other parts of Berkshire county.

No. 163 *b* was obtained from what is called the Jewett farm, in the north part of Rowley, on the road to Newbury. It occurs in a low spot of ground, and has been formerly used for painting a house. The specimen is of a coarser texture than those from New Marlborough: but the former excavation was nearly filled up, and I had no time to have it re-opened; so that, perhaps, this specimen does not exhibit a fair sample of this locality.

No. 161 *b* was sent me from Athol, by Alden Spooner, Esq., who says that it occurs in the north part of the town, and also in Templeton; but he gives no farther particulars.

No. 162 *b* is from Monroe, for which I am indebted to Martin Ballou Esq. He informs me that it was formerly dug to some extent and prepared for paint; but not being in much demand, the work was abandoned. It certainly appears as if it might be valuable.

No. 216 *b* is from Bedford: but I am not informed as to its extent.

At one of the beds of iron ore in Richmond in the eastern part of the town, a large quantity of yellow ochre has been thrown out; and I doubt not but it might be employed for paint. In Williamstown also, as already described, a bed of it was formerly dug and the article used. No. 217 *b* is from Harwich; where it occurs beneath peat, several inches thick. A reddish ochre is found in Boylston, mixed with clay.

The peculiar fossil paint called *apothemite*, lately found in Newbury, has already been described, when treating of the subject of soils. It has also been mentioned, that the phosphate of iron found in Hopkinton, near the mineral spring, has been used as a blue paint.

In Hatfield, is an immense quantity of the sulphate of baryta of a superior quality. Within a few years, a patent has been taken out in England, for the use of this substance as a paint, to be employed in those situations where lead paint is liable to be acted upon by moisture, acids, and other chemical agents. In such cases this barytic paint is excellent. I have been in the habit, for several years, of having various articles in the laboratory, such as the pneumatic cistern, gazometers, &c. covered with it; and it answers a good purpose, although I have prepared it not according to the patent, but simply by grinding it in a plaster mill and mixing it with oil. The greatest defect in this paint, seems to be, that it has less body than lead, although I doubt not that a remedy may be found for this difficulty. When the baryta is thoroughly pulverized, and mixed with boiled linseed oil and lampblack, it is superior to any thing I have ever seen, for labeling glass bottles, &c., in a laboratory, and indeed for any situation exposed to active chemical agents.

In this case, however, I have usually decomposed the sulphate of baryta in order to purify it, converting it first into a carbonate, and then back again into a sulphate. In whiteness it then equals the best white lead.

This mineral occurs at Southampton lead mine; also in Leverett with galena; and with copper ore in Greenfield: and in quantity sufficient to furnish a good deal of paint. But the Hatfield locality is by far the most abundant. Nor can I believe that a substance capable of such useful application, will be much longer neglected.

Other rocks, also, which have of late been used as lithic paints, abound in this state. Soapstone, of which we have such inexhaustable quantities, is considered best for this purpose, and serpentine is also employed. These are ground with whale oil; and in Connecticut, where they have been manufactured, they are sold for five dollars per hundred pounds. They answer a good purpose as a basis for common paints, especially for the roofs of houses. I should presume that the newly discovered serpentine in Lynnfield is very well adapted for this object, being unusually soft and free from foreign minerals.

10. *Arenaceous and Granular Quartz.*

From some unknown cause, the granular quartz in Cheshire, Berkshire county, is so much disintegrated, that it easily crumbles into a beautiful white sand. This forms a good material for glass, and has been employed for this purpose a number of years; formerly in Cheshire and Warwick, Mass., and in Utica, N. Y.; and at present in Keene, N. H. It answers well for crown and cylinder glass. The quantity is inexhaustable. It is sold at the road, one mile from the bed, at 6 1-4 cents per bushel. The sand is employed extensively in Berkshire in the process of sawing marble.

I am inclined to believe that some of the sand associated with the tertiary and diluvial formations in the State, particularly in the gneiss region, is pure enough to be employed in the manufacture of coarse kinds of glass: such for instance as is found in Pelham and Leominster. The purest and coarsest variety, however, that I have met with, forms the shores of Lock's Pond, in the northwest part of Shutesbury. This sand has been recently employed with success as a substitute for smalt, upon doors exposed to depredations from penknives and pencils.

A very beautiful sand (No. 21 *b.*) occurs at Squam, in Gloucester, of which great quantities are transported to Boston. Some of the sand on Cape Cod also is pure enough for the manufacture of glass.

In Berkshire a good deal of sand is used in the sawing of marble: and the arenaceous quartz furnishes an excellent material for this purpose. In some parts of the county, however, the transportation of good sand is expensive. Now as bowlders of granular quartz occur in almost every town, I would suggest that these be burnt in a lime kiln, until, thoroughly ignited, and then let cold water be thrown upon the pieces; which will dispose them to fall into fine sand. It may be necessary to use a hammer: but even in this case it might be often less expensive than to transport the sand from a great distance.

11. *Materials for Millstones.*

In the same hill that furnishes the flagstones and fire stones in Washington, a few miles from Pittsfield, there is found a singular porous quartz, considerably resembling buhrstone, which is employed for millstones. These are prepared near the ledge and sold for 70 or 80 dollars each. I am told that they answer well, especially for the coarser kinds of grain. They are doubtless inferior to the real buhrstone; because they are less tough. The quantity is inexhaustible. This rock, to my surprise, I find to be derived from gneiss, by the decomposition of the feldspar. But this change will be more particularly described in the scientific account of rocks that will be subsequently given.

Sometimes our citizens employ the finer and more compact varieties of granite for millstones. I have seen even a coarse *conglomerate*, or *puddingstone*, used for this purpose. And while upon this subject, I cannot but express my surprise that no attempt has been made to employ our greenstone, and other hornblende rocks, for millstones. In Great Britain, basalt has been, within a few years, used for this purpose, and found even superior to the French buhrstone; and our greenstone is only a variety of the same rock: indeed, some of our greenstone cannot be distinguished, by the eye, from the European basalt. It is generally extremely compact and tough; and although its preparation might require a little more labor than the buhrstone, yet it would doubtless last enough longer amply to pay for the additional labor. In the vicinity of Boston and in the Connecticut valley, as may be seen on the Map, greenstone exists in great quantities. It also occurs in small beds throughout the whole extent of the gneiss region in Worcester county; and of a kind, which would answer the purpose even better than that of the extensive ranges above mentioned.

22. *Polishing Materials.*

No real emery has yet been found in Massachusetts. But in North Brookfield, a rock composed chiefly of garnet, has been used as a substitute; as it is in Saxony and Bohemia. It is said to answer well, and is often called *red emery*. (No. 1079.)

I would suggest that probably a useful polishing powder might be prepared from the garnets that are so abundant a little distance south of the center of Warwick. (Nos. 2133. 2134. 2135.)

At Paine's quarry of limestone in West Springfield, I found a mineral which subsequent examination has convinced me is genuine tripoli or rotten stone: and it appears to be of a good quality. It occurs too in large quantities, and under circumstances similar to those in which it has been found in other parts of the world. I mean that it is associated with fetid limestone; being in fact that rock partially decomposed, and still emiting a strong fetid odor when struck. I hope that some mechanic, who has occasion to use this article, will thoroughly test that from Springfield, as I know of no other locality of any importance in the country. It does occur, however, at South Hadley falls on the West Springfield shore. But the quantity is small, and it is not there associated with limestone, but appears to be an altered shale. (Nos. 217 to 221.)

The fine siliceous matter that is sometimes mechanically deposited in the bottom of ponds, is frequently employed for scouring metals, where great delicacy is not required. The hydrate of silica, especially that most remarkable product of animalculæ, which has been described in its agricultural connection, forms an excellent polishing powder: as we might expect from the extreme fineness to which the silica must be reduced to form their skeletons.

13. *Alum Rock.*

It is well known that alum is often formed in rocks by their spontaneous decomposition, which may be aided by artificial means, and thus large quantities be obtained: for alum being soluble in water, is easily separated from the mass by lixiviation. Any rock that contains sulphuret of iron, potassa, and alumina, may produce it. I have found it in considerable quantity upon the gneiss of Leominster, Barre, and Ware. (Nos. 1080. 1081.) It occurs also upon mica slate in the northwest part of Conway. In all these cases it is found efflorescing upon the slate, and the rock in Conway resembles that which in England is called alum slate; that is, a variety of mica slate, which is passing into clay slate: so that if upon trial this rock be found to furnish a large quantity, the alum might profitably be manufactured. The same may be said of some localities in Berkshire County; as in Sheffield, where it is said that pounds of alum can be collected in a nearly pure state. As to the alum upon gneiss, it is found in delicate plumose masses upon that schistose variety of this rock which approximates to mica slate.

There is mixed with this alum more or less of sulphate of iron, and both minerals proceed from the decomposition of iron pyrites, and probably feldspar. This last mineral contains, as is well known, a considerable quantity of potassa; and I can imagine no other source from whence this essential ingredient of alum should be obtained. Nor will any one doubt, who has seen how thorough is often the decomposition of the gneiss that contains pyrites, that this potassa might be separated. I am not aware that alum has been heretofore found in gneiss; but since this rock does contain so much potassa, and if it can be thus separated from the feldspar, why may not our gneiss prove a very prolific source of alum? I do not know that any special efforts have been made to ascertain whether it can be procured in much quantity from the rock in Leominster: but recently I have received a specimen from Barre, and it occurs also in Ware. And I can have no doubt that any part of the gneiss range, where pyrites is decomposing, will produce it. It may be hoped that a fair trial will erelong be made to obtain this substance. It would be premature in this place, to make suggestions as to the best mode of proceeding.

Suffice it to say, that no effort should be made on a large scale, without consulting some practical chemist.

14. *Graphite, Plumbago, or Black Lead.*

This substance has the color of lead, leaves a trace like that metal upon paper, and bears the common name, *black lead;* but it contains no lead. It is composed of above 90 per centum of carbon, and the rest is iron and earthy matter. Hence it differs but little from some varieties of anthracite. It seems indeed to be the form in which carbon occurs in the oldest of the rocks. In Massachusetts it exists in gneiss, at the most important locality, which is in Sturbridge. It there occurs in a bed, varying in width from an inch to about two feet, and traceable along the surface, nearly one hundred rods. A number of years ago this bed was opened; and several tons of the graphite obtained. It was then abandoned; but within a few years the exploration has been recommenced, and already more than a hundred tons have been obtained. In some places the excavation is 60 or 70 feet deep. The quality of the graphite is excellent, and would not suffer by comparison with almost any in the world. (Nos. 1073 to 1075.) To what extent it may be obtained, it is not possible at present to determine. The fact, that the bed descends, almost perpendicularly, into the earth, is rather unfavorable to the miner. Yet, as it is found upon elevated ground, the mine can be conveniently drained by lateral cuts or adits to a considerable depth: and probably the exploration may be profitably continued for a long time with little machinery.

The plumbago mine above described is owned by Mr. Tudor of Boston, and yields annually about 30 tons of this mineral. It would not be strange if a drift across the strata at that place, should bring to light other beds; as they frequently occur near together with a few feet or yards of intervening rock; and as this is a valuable mineral, such an exploration might be desirable. A few miles east of this spot, on land of a Mr. Morse, quite an excavation has been made in the gneiss in pursuit of graphite: And indeed, a thin bed of it, not more than an inch or two thick, exists there: But there is a also a good deal of mica slate in thin layers, which much resembles graphite, because glazed by it; and I presume this has been mistaken for it. Such rock is quite common in the mica slate region west of Connecticut river; and indeed, real graphite occurs there; as in Cummington, Chester, Worthington, &c. I am told also, that it exists in beds of considerable thickness in the mica slate of Halifax, in Vermont; a little beyond the Massachusetts line. From the specimens sent me by Dr. James Deane, I should think this locality deserving the attention of those who would like to engage in mining operations. Plumbago also occurs in North Brookfield, Brimfield, New Marlborough, and Hinsdale.

I have already intimated that a good deal of plumbago is mixed with the anthracite of Worcester. In the south part of Millbury is a mill, at which large quantities of this semi-plumbago is ground. It is put into casks and sold in New York; but I could not learn certainly to what use it is applied.

15. *Glazing for Porcelain.*

The articles of pottery and porcelain made from white clay need to be covered with a glaze of some other substance: that is, with an enamel, or glass: for the clay in its pure state does not melt in common furnaces. Now feldspar and albite, whose composition is very much alike, except that the latter contains soda and the former potassa, on account of the alkalies in their composition, may be melted in a strong heat; and hence they are employed for the most delicate kinds of glazing. Common glazing, which consists of powdered gun flints, litharge and table salt, is so soft as soon to yield to the mechanical and chemical agents to which the articles are exposed; and it would be very desirable that feldspar might be employed in all cases, though, as the process for its preparation is at present conducted, it would be more expensive.

I know of no attempt to employ any of the feldspar of Massachusetts for glazing; and yet we possess in our granites, sienites, and gneiss, inexhaustable quantities; and much, no doubt, pure enough for this purpose. Can there be any doubt, for instance, that the adularia of Brimfield, Southbridge, &c. would furnish a most admirable article, since it is nothing but the very purest variety of feldspar. The best locality of albite in the state is in the north-west part of Chesterfield, on the farm of Mr. Clark: and I have understood that it was purchased not long since, by a company in New York, for the purpose of using it in the manufacture of China ware, or porcelain: but I have not learned whether they are now prosecuting the work.

Beds of feldspar and albite have been quarried in Connecticut, within a few years past, with much success. In Middletown alone, in the year 1836, seven hundred tons were dug out; six hundred of which were shipped to Liverpool.*

16. *Substances used by the Dentist for artificial Teeth.*

The enamel from which artificial teeth are prepared, is obtained by the fusion of pure feldspar. Now there cannot be purer feldspar than some of the adularia described in the preceeding section. I am not aware that any of it has been yet tried for this purpose; but can hardly conceive that some of the localities in the state should not yield the very best variety.

The dentist colors his enamel for teeth by rutile, or the red oxide of titanium. This also can be obtained in quantity sufficient for the purpose at several localities in the state. Perhaps the best is in Windsor, at the east part of the town, on a branch of Westfield river. Another locality of interest, recently discovered, is in the west part of Barre.

17. *Prospective Source of Potassa.*

While our forests yield so large a supply of fuel, from the ashes of which potassa can be obtained, we shall not need to resort to any other source for this valuable substance. But when this source fails, it is gratifying to know that we have another that is inexhaustable. Pure feldspar, contains nearly 20 per cent. of potassa; and it has recently been proposed to separate it by calcination with lime, and subsequent lixiviation. There can be no doubt but it might thus be

* Prof. Shepard's Geological Report, p. 72.

separated; and it might also be obtained from mica: which contains 16 per cent. Albite, which is usually regarded only as a variety of feldspar, treated in like manner, would yield 9 or 10 per cent. of soda. Hence we may be sure that Massachusetts can never be in want of these important alkalies, until her granite and gneiss mountains shall be destroyed.

18. *Prospective Source of Lithia.*

Lithia is an alkali similar to potassa and soda, which has not been known many years, and has been obtained only in small quantity, chiefly from two minerals, which in Europe are quite rare: viz. petalite and spodumene. But in Massachusetts these minerals exist in large quantity; especially the spodumene, at Goshen, Chesterfield, and Sterling. They contain from 6 to 8 per cent. of this alkali; and should it prove useful, as an alkali is very likely to do, here is a fertile source from whence it may be derived, by chemical processes, which it would be out of place and time here to describe.

19. *Substitute for Animal Charcoal in the Clarification of Liquids.*

The syrups of sugar and other liquids are frequently clarified by means of animal charcoal. But of late it has been found in France, that a variety of bituminous slate answers well as a substitute. Aud the description given of it corresponds so well to that of the bituminous slate on which are found the impressions of fish at Sunderland, that it seems desirable a trial should be made of the latter. It should be burnt, or charred, in kilns, like charcoal; and then pulverized; when it is ready for use. Pieces containing sulphuret of iron should be avoided.

20. *Mineral Springs.*

No mineral springs of much notoriety are found in this State, although chalybeate springs are very common, and are useful in cutaneous and some other complaints. Nearly all these springs rise in low ground containing bog ore. The Hopkinton spring is of this description, and is probaly more resorted to than any other in the State. This contains, among other ingredients, carbonic acid and carbonate of lime and iron. The spring in Brookfield is similarly situated, and contains some magnesia and soda, as well as iron. It is a place of some resort. A mineral spring exists in Shutesbury, abounding in muriate of lime, and it is somewhat visited. Chalybeate springs exist in South Hadley, Amherst, Deerfield, and indeed, in almost every town in the State. In Mendon I was shown a mineral well, in the waters of which, chemical tests indicate muriate of lime and carbonic acid in a free state. No use was made of the water, except as a substitute for yeast.

New Lebanon is well known as the locality of a thermal spring, which attracts considerable company. It is situated only a short distance beyond the line of Massachusetts, and on the western slope of the Taconic ridge, which separates the two states. The saline ingredients are in very small quantity in this spring, and of no consequence in estimating its medicinal properties. The two circumstances that give this spring its chief interest, are its elevated temperature, and the constant escape of gas from its surface. According to Dr. Daubeny, who has recently examined this spring, its temperature is 73° F: while that of springs in the vicinity is 52°. The gas given out he finds to consist of 89.4 parts of nitrogen, and 10.6 parts of oxygen in 100 parts.

In Williamstown there exists a similar spring, issuing from the midst of diluvium, and at the western base of a mountain of quartz rock. Its temperature is not so high as that of the Lebanon spring, and it has been said that the gas which escapes is the same as atmospheric air. But this point needs re-examination by a careful analysis. This spring is not much resorted to for medicinal purposes.

I have lately discovered a spring of the same character in Mount Washington, near the south west corner of the State. It is upon the farm of a Mr. Schott, who lives in the west part of the town; and it must be at least 1000 feet above the valley of the Housatonic; and not far from the highest part of the Taconic range of mountains at that particular place. Hence its situation is very similar to that of New Lebanon: though talcose slate is the only rock in Mount Washington, whereas the Lebanon spring is near the junction of that rock with limestone. The Mount Washington spring also, must be nearly 1000 feet more elevated than that at Lebanon. At present the gas rises only over a small spot, a few inches in diameter: but I presume that were the soil removed around this spot a few inches in depth, the water and the gas would rise from a much larger area. The temperature of this spring, May 3d. 1839, was 46° F: and a spring that did not emit gas, several hundred feet lower than the one just described, and on the path to Bashapish Falls, was the same. This is on the western side of the Taconic range. But the temperature of a well six feet deep, at Mr. Schott's house, was 43°. Another spring, issuing from a hill of limestone in Egremont, the same day, was 44°. Another spring in the east part of Lee had the same temperature the day previous. But a well, 8 or 10 feet deep, at the public house on the old turnpike through Becket, had a temperature of only 38°. This is the coldest water that I ever met with in a well as deep; and I was told that it is remarkably cold through the summer. Upon the whole, I think we may fairly infer that the gas spring in Mount Washington has a temperature a little higher than others in the region; and therefore may be called a thermal spring.

I made an analysis of the gas from this spring by means of spongy plantinum and clay with hydrogen, and found it as follows, in 100 parts:

Oxygen,	4.5
Nitrogen,	95.5
	100.0

With lime water I could not detect any carbonic acid. I ought, however, to mention, that the gas was brought 70 or 80 miles in a bottle with some of the water, before the analysis was performed. But I could not perceive that any absorption had taken place.

Concluding Remarks.

In taking a general view of the mineral resources of Massachusetts, the mind selects at once, as the most important objects, the iron and limestone of Berkshire county, and the granite of Essex, Norfolk, Bristol, and Plymouth Counties. Which of these are the most important in an economical point of

view, I shall not pretend to decide. But of three things I feel confident: First, that there exists in these portions of the State, an inexhaustible supply of these materials: secondly, that for generations to come, there will be an increasing demand for them from abroad: And thirdly, that the community in general have as yet but a very inadequate apprehension of the great pecuniary value of these vast deposits. The fact that it requires industry and ingenuity to bring these materials into a marketable state, I regard as enhancing their value: For it cannot be doubted, that an income which is the fruit of vigorous bodily and mental effort, is of twice more value than one obtained without either. Berkshire possesses the advantage of possessing the greatest variety of useful minerals; and hence is to be regarded as the chief mineral district of Massachusetts. But the granite of the eastern part of the State is directly accessible in many instances to ship navigation; while even with the increased facilities of rail roads, so propitiously commenced, the western part of the State must be of comparatively difficult access. So that upon the whole, it is not easy to say which part of the State possesses mineral resources of the greatest economical value.

I think that those who read my report on our Economical Geology, will be satisfied that there are numerous mineral deposits in the State of no small promise, yet undeveloped, or only very imperfectly made known. Who can doubt that the rich porphyries, and other ornamental rocks, that exist in such profusion and variety around Boston, will one day be found gracing the parlors of the wealthy and the tasteful? Who will believe that our numerous and extensive deposits of serpentine, will never be drawn from their hiding places and made the ornament of our public and private edifices? Nor is it an extravagant belief, that some of our gems may one day be in a measure substituted for those from foreign countries. In the central parts of the State, are immense deposits of stratified as well as unstratified rocks, that would vie with those on the coast for purposes of construction; but which now lie almost untouched; because so far from market: Yet the facilities of transportation are increasing so rapidly that we may hope that even these deposits will some day, be sought after from a distance. Then also will our numerous beds of soapstone become objects of commercial value. We have grounds also to hope much from the coal field of Norfolk and Bristol Counties; and something perhaps in this respect from the valley of the Connecticut. It is not a mere dream of fancy that inspires the hope that Hampshire County may hereafter become the chief lead yielding district of N. England; as any one, who is acquainted with its geological structure, and the numerous unopened veins of galena that show themselves at the surface, will admit; and I strongly anticipate the discovery there of tin in workable quantity. Franklin County, also, may yet supply a large district with copper: for her

surface certainly exhibits veins of that metal; and it is known that these ores are not apt to put on their best aspect at the surface. Warwick, Hawley, Bernardston and Montague, may yet set in operation numerous iron furnaces, with their magnetic ores; which, though less valuable than the iron mountains of Missouri and New York, may yet be of great importance. We hope something also from the chrome ore of Chester; as we do also from numerous other substances whose existence and uses have been pointed out in this Report.

If we recollect, also, how many mineral resources exist in the State, capable of being applied to the improvement of our soils, but which are scarcely yet known to the community, we shall indulge in still more sanguine expectations respecting the future condition of Massachusetts. The vast deposits of peat and peaty mud in our swamps, if properly applied, might convert two thirds of the State into a garden. To aid this work we have our limestones, our marls, our marly clay, our clay, our muck sand, and perhaps also our green sand; most of which substances are widely diffused, but which have as yet scarcely begun to be used.

If Massachusetts then is not recreant to her true interests, she will continue to encourage the development of her terrene and subterranean resources. For every successful application of these, will add to her wealth, her population, and her means of usefulness and happiness.

PART II.

SCENOGRAPHICAL GEOLOGY

OF

MASSACHUSETTS.

I HAVE supposed that my account of the Geology of the State would be quite imperfect, without some notice of our Scenery. Strictly speaking, indeed, scenery is not geology: and yet the contour of a country owes its peculiarities in a great measure to the character of the rocks found beneath the soil: so that the geologist, by a mere inspection of the features of the landscape, can form a very probable opinion of the nature of the rock formations. The extended plain, he will pronounce alluvial, or tertiary. The precipitous ridge or mountain, if dark colored, and unstratified, will indicate trap rocks; if light colored, granite: if the summit be rounded, and the aspect red or gray, he will suspect it to be made up of sandstone. The more extended and less precipitous mountain ranges, stretching away over many a league, correspond more nearly to the outlines of primary rocks.

But diluvial and alluvial agencies, above all other causes of Geological change, have contributed to give the surface of the earth its present outlines. Many a mountain top has been indented by vallies, and many a mountain's base has been surrounded by gravelly conical elevations, almost as if the work of art—by those diluvial agencies of which we find almost every where the traces, however difficult it may be to explain their causes. How many wild and profound gorges, cut through solid rock; how many beautiful meadows, sometimes bordered by terraces; have been the result of those aqueous operations that are now going on from day to day!

The vegetable covering of the surface depends also, very much upon the chemical nature of the rocks beneath. In the valley of Connecticut river, for example, how strikingly different is the rich and dense foliage of the alluvial meadows, from the uniform and stinted pines and shrub oaks of the diluvial plains! and how different from both, is the vegetation, when in the same valley, the marly red sandstone breaks its way to the surface! On the margin of this valley, also, where rises the precipitous trap ridge, how very peculiar is the vegetation that covers it! Compare too, the plants of that

ridge with those upon the talcose slate soil of the Taconic range of mountains. The latter is almost covered with the lofty and graceful chestnut, while the former sustains the Quercus montana or chestnut oak; the Juniperus Virginiana, or white cedar; the Acer Pennsylvanicum and montanum two dwarf species of maple, very unfrequent upon most formations.

The planes of structure in rocks, likewise, give them peculiarities of aspect. Very different, for instance, is the columnar structure of many traps, from the irregular fissures of granite and porphyry; and usually from the divisional planes of the stratified rocks. As a result of difference of structure, very unlike will be the operation of disintegrating agents; and the various forms that are thus produced, will reveal to a practiced eye at a distance the character of the rock.

From these and other considerations that might be named, we may safely assume, that the peculiarities of natural scenery depend chiefly upon geological causes; and hence I have thought it would not be a misnomer, to denominate a description of natural scenery, *Scenographical Geology.* With the modifications of natural scenery by human agency, I have little or nothing to do in this place. My chief object will be to call the attention of men of intelligence and taste, to those striking features of our scenery, that are the result chiefly of geological changes, and which produce landscapes abounding in beauty and sublimity. A few of the more frequented of these spots are well known: but very many of them have cost me much time and labor to discover; quite as much indeed, as to find out new localities of rocks and minerals: although the two objects could be conveniently prosecuted together. Some of them are yet too little known to have received a name; and in a few instances I have ventured to supply this deficiency. It will not be expected that I should describe these spots with the vividness and minuteness of the poet and the painter. My chief object has been to direct the attention of gentlemen of taste, intelligence, and leisure, to these spots; that sometime or other, their beauties and sublimities may be faithfully depicted, both on canvass and in language. In this way I hope that many of our citizens, in their excursions for relaxation and health, instead of following the beaten track to places of fashionable resort, where more is often lost in morals than is gained in health, may be induced to climb our own mountains, and traverse our own deep glens and gorges, where they will find unsophisticated nature, with the dress given her by her Creator, scarcely marred by the hand of man. In order to excite more interest in our scenery, I have succeeded in obtaining, through the liberality of several individuals,* who

* The names of the individuals to whom I am indebted for this gratuitous service, will be found upon the sketches which they have taken, except in a few cases, where a lady from New York was too diffident of her skill with the pencil to allow her name to appear.

possess a talent for drawing, quite a number of landscape sketches: and although wood cuts and even lithographic sketches can do but imperfect justice to these spots, yet I thought that even these would be preferable to naked description.

It should be remarked here, that many of the sketches were taken with a view to illustrate the geological features, as well as the scenery; and wherever it was possible to unite these two things, I have done it. This is especially the case in those sketches that contain exhibitions of diluvial phenomena. And I cannot but observe here, how superior must be the pleasure which the geologist derives from scenery, above that of the man who knows nothing of the mighty agencies by which the striking features of that scenery have been produced or modified. The latter derives all his pleasure from the simple beauty or sublimity of the spot. But along with that emotion, the mind of the former is stimulated and regaled by numerous rich and delightful associations. It is carried back through immense periods of past time, during which natural causes were operating to produce the scenery before him: and he witnesses in imagination that spot, assuming peculiar and widely diverse aspects; and sees how wisely each change was adapted to bring it into its present state. It may be too, that his mind reaches forward into futurity; and perceives other changes passing over the spot, no less interesting; and the necessary consequence of the unalterable laws which God has established.

The most striking objects in the scenery of a country, where they exist, are high and precipitous mountains; especially if extensive plains, traversed by rivers, stretch away from their bases. I shall therefore, in the first place, describe those conspicuous peaks and ridges in the State, whose summits afford wide and interesting prospects.

Massachusetts is peculiarly mountainous. But mountain scenery is not particularly interesting, if the slopes are gentle, and the outlines of the hills are much rounded. It needs the sharp towering peak, the craggy and overhanging cliff, and the roaring torrent beneath, to arrest the attention, and excite strong emotions. Such objects are numerous in this State, especially in the western part. Here we find some scenery that is truly Alpine. I begin with the highest point in the State, viz.

Saddle Mountain.

We have in Massachusetts 3 rather lofty and extensive ranges of mountains, crossing the State in a north and south direction. The summit of the Taconic range, corresponds nearly with the west line of the State. The Hoosac range is separated from the Taconic by a valley several miles in width. The former occupies all the eastern part of Berkshire County, and the Western part of Franklin, Hampshire and Hampden; being from 30 to 40 miles broad, and

extending easterly to the valley of the Connecticut. East of this valley is a belt of mountainous country, embracing the eastern part of Franklin, Hampshire and Hampden Counties, and the whole of Worcester County: but no specific name has been applied as yet to this range as a whole.

Saddle Mountain does not belong, properly speaking, to any of these chains of elevated land; though generally regarded as a spur from the Hoosac range. But it is in fact an insulated eminence, which is connected at its southern extremity with the Taconic range and on the north with the Hoosac range, running diagonally between them, mostly in the town of Adams, and nearly surrounded by valleys, above which it rises 2,800 feet, and nearly 3,600 above the tide water of the ocean. It is chiefly the insulated character of this mountain, that renders it so striking an object in the scenery. Its summit is supposed to bear a resemblance to that of a saddle; and hence its unpoetic name. The highest point of the summit has a much more appropriate designation, viz. *Graylock;* from the hoary aspect which the upper part of the mountain presents in the winter months. During that season, the frost attaches itself to the trees, which, thus decorated, it needs no great stretch of imagination to regard as the gray locks of this venerable mountain. As the cold increases, the line of congelation sinks lower and lower, covering more and more of the mountain with frost work; and a contrary effect results from an increase of the temperature; so that this line is frequently rising and falling during the cold months, producing numerous fantastic changes in the aspect of the mountain.

The best route by which to ascend to the summit of Graylock, passes up the southwestern declivity of the mountain, through what is called the *Hopper;* and over that spur of the mountain denominated Bald Mountain. The ascent is so gentle that it may be gained on horseback. At present one is obliged to climb a tree, to the height of 30 or 40 feet, in order to get an unobstructed view from the summit; so that either the surrounding trees should be cleared away, or a stone or wooden structure be erected, that would overlook them. This work I am happy to find is in part completed, and efforts are making to construct even a carriage-road to the summit.

I know of no place where the mind is so forcibly impressed by the idea of vastness, and even of immensity, as when the eye ranges abroad from this eminence. Towards the south you have a view, more or less interrupted by spurs from the Taconic and Hoosac ranges of mountains, of that fertile valley which crosses the whole of Berkshire County. On your right and left, you look down upon, or rather overlook, the Taconic and Hoosac mountains; which, from the valley beneath, seem of such towering height and grandeur. Beyond these mountains, on every side, you see the summits of peak beyond peak, till they are blended with the distant sky.

Upon the whole, however, I was more interested by the phenomena exhibited in that part of the mountain called the Hopper, than by a view from the summit. As the traveller descends from Graylock, let him follow out the naked summit of Bald Mountain nearly to its extremity, and then, on turning northerly, he will find before him a gulph at least a 1000 feet deep, the four sides of which seem (although it is not strictly so in fact,) to converge to a point at the bottom. The slope of these sides is so steep, that one feels dizzy on looking into the gulph. These slopes are all covered with trees of various species, among which are occasional patches of evergreens, giving to the whole a rich and captivating appearance. On the northeast side, however, may be seen the traces of several *Mountain Slides*, by which the trees and the loose soil have been swept away from the height, in some cases, of 1600 feet, and of considerable width. It is not more than ten or twelve years since one or two of these slides occurred; and the paths which they left behind, are yet quite naked of vegetation. In some instances of earlier date, we perceive the vestiges of the avalanche, only in the stinted growth, or peculiar character of the trees, that have sprung up. It is said that one of the most remarkable of these slides took place in the year 1784; and that one dwelling house was swept away by the inundation, though the inmates escaped.

If we start from the village of North Adams, we can pass up around the north end of Saddle mountain, perhaps two thirds of the way to the summit of Graylock: and proceeding to the western side of that summit, we come to a large elevated spot, improved as a pasture, and which forms the southern end of the Hopper that has been described. That deep valley here assumes a different appearance from that just described, as seen from Bald Mountain, but almost equally imposing. On turning northerly, and proceeding to the extremity of the open ground, we come to the steep margin of the mountain; and in a moment the beautiful valley and village of Williamstown, with the Colleges and Astronomical Observatory, burst like a bright vision upon the eye. On your right, the vast slope of Hoosac mountain, stretching away into Vermont; and on your left, the vast slope of the Taconic range, stretching northerly still farther; while beyond and above it, the lofty mountains in N. York west of Champlain, appear; and between the Hoosac and the Taconic, Bald mountain, a lofty eminence in the north part of Adams, rises near you in silent grandeur. In fact, I have rarely if ever experienced such a pleasing change from the emotion of beauty to that of sublimity, as at this spot. The moment one fixes his eye upon the valley of Williamstown, he cannot but exclaim "how beautiful!" But ere he is aware of it, his eye is following up and onward the vast mountain slopes above described; and in the far off horizon, he witnesses intervening ridge after ridge, peering above one another, until

they are lost in the distance; and unconsciously he finds his heart swelling with the emotions of sublimity nor can the soul of piety cease its musings here, until the tribute of reverence has been paid to that Eternal Power, who has driven asunder these everlasting mountains. This is decidedly the best view that can be obtained from Saddle Mountain.

Before one gets an accurate idea of this stupendous mountain, he must pass over it and around it in a variety of directions. I find it to consist essentially of three distinct ridges, running nearly N. 30° E. and S. 30° W. the middle one being several hundred feet the highest, and constituting Graylock. The western one more usually goes by the name of Saddle mountain. The easterly ridge is narrow and precipitous; and is separated from the middle one by a fertile valley, whose north end is nearly on a level with the valleys of North Adams and Williamstown. But it gradually ascends for several miles, until at its southern extremity, it is more than half as high as Graylock, and nearly as high as the eastern ridge of the mountain, which is thus connected at its southern extremity with the central ridge. The valley is improved throughout; and is called the Bellows, from the fact that it becomes gradually narrower towards its highest part; and when the wind is in the right direction, to blow through it southwesterly, it passes through the narrowest part with great violence. In like manner the western ridge of the mountain is separated from the central ridge by a valley, already described as the Hopper, whose bottom, at the southwestern part, is almost as deep as Williamstown valley; but in passing northeasterly, it gradually fills up until we reach the lofty cleared spot already described, which overlooks Williamstown; and there the western and central ridges unite. So that on each side of the middle ridge, we have similar valleys but sloping in opposite directions. I ought to mention that a splendid southern view is obtained from the upper part of the Bellows; though scarcely equal to that on the northwest side.

During one of my visits to this mountain, the wind was strong from the northwest, which caused it to strike the ridges nearly at right angles. I passed up from North Adams through the whole length of the valley called the Bellows; and found the wind blowing very strong directly through the valley; that is, nearly from the northeast. I then passed around the north end of the middle ridge, or Graylock, and found the direction of the wind the same as in Adams: that is, from the northwest. But when I had passed beyond the middle ridge, and came to the northern extremity of the Hopper, the wind rushed up violently from the southwest nearly:—that is, in a direction exactly opposite to its course in the Bellows. But the explanation of these curious facts is easy. The northwest wind, when it struck against the middle ridge of the mountain, which at its southern extremity curves con-

siderably towards the west, was forced northerly up the valley of the Hopper, so as to come from the southwest. But the wind that passed over and around the northern part of Graylock, striking against the eastern ridge, was turned southwesterly, through the valley of the Bellows; so as to give it a direction from the northeast. But when we rose high enough to be out of the reach of these deflecting slopes, the wind preserved its general course from the northwest. It is not probably, however, very common, that a wind would strike the mountain at precisely that angle which would produce this paradoxical phenomenon.

Fig. 8, is a distant view of Saddle mountain as seen across a beautiful sheet of water in Pittsfield, called the Pontoosuc Lake.

Fig. 8.

Saddle Mt. across Pontoosuc Lake.

Oak Hill, or Bald Mountain.

This lofty eminence may be regarded as a continuation of Saddle mountain northeasterly; though the two are separated by a deep and narrow valley through which the road passes from Adams to Williamstown. The southern part of Bald mountain is broad and gently rounded; and being covered with woods, no interesting prospect exists from its summit. Yet from its southern slope you have a delightful view of the village of North Adams with the deep valley stretching away southerly between Hoosac and Saddle mountains: a view that well repays the labor of climbing the ridge to the height of 1000 feet. The top of the ridge must have a greater elevation than this: and in following it into Vermont, where, if I do not mistake, it unites with the Hoosac range, there are peaks still more elevated.

The Bald mountain just described must not be confounded with the southwest part of Saddle Mountain which also bears that name.

Hoosac Mountain.

Hoosac mountain is a continuation southerly through Massachusetts, of the Green mountains of Vermont. Yet the name, Hoosac mountain, is not

usually applied to the range, except in the northerly part of the State. In Peru, it is called Peru mountain; and in Washington, Washington mountain. But in this work I have spoken of the whole range in Massachusetts as Hoosac mountain; for it seems undesirable to give different names to different parts of the same continuous range, unless some particular peak peer above the general surface. This mountain is for the most part very steep on the west side: but on the east, the slope is more gradual; and indeed, it may be considered as extending to the valley of Connecticut river. The main ridge, however, is near the western side; and this gradually diminishes in elevation as we go southerly.

So high and steep is this ridge, that it is no easy matter to find a proper passage for a road across it into the valleys of Berkshire. Yet several have been opened, where stages pass: One, for instance, through Florida, another through Savoy; another through Peru; another through Washington; another through Becket; another through Otis; and another through Sandisfield. And what is still more unexpected, a passage has been found for the Western Rail Road through the Pontoosuc valley. Where these roads cross the highest part of the ridge, splendid prospects are often presented; especially towards the West, where the deep valleys of Berkshire give magnificence to the towering Taconic range beyond, and the still more lofty and distant Catskills. Turning towards the east, the observer sees successive ridges of mountains with their summits now rising above, and now sinking below, one another, over a vast area.

Taconic Range.

Commencing on the west of Williamstown, this lofty ridge forms almost a continuous range across the State, whose summit corresponds nearly with the line between Massachusetts and New York. On its western side, it is even more bold and precipitous than Hoosac mountain; and hence splendid prospects arrest the traveller's attention, who climbs to the summit, at almost any point. The higher the ridge, of course the wider and more imposing the prospect. But I have met with none that demand peculiar notice, till we reach the southwestern town in the State; where we have a vast mountain pile that will be described farther on. The roads over the Taconic range are much fewer than those over the Hoosac, though in several instances they pass through valleys cut through the range. The stage road from Pittsfield to Albany affords perhaps nearly as good a prospect from its highest part, as any other; though a view from an unfrequented road from Hancock to Lanesborough, is more striking. Yet as we begin to descend westerly from the summit on the Pittsfield road, the view is magnificent as well as beautiful.

Tom Ball.

In proceeding southerly from Pittsfield, we are met on the right, by the northern termination of a lofty mountain ridge, rising abruptly from the plain. If we pass to the right of this bluff, we shall find a valley leading us through Richmond to West Stockbridge. If we go to the left, we shall find ourselves on the road to Lenox. But on either road we shall find in our horizon the high ridge just described; and following it onward, we shall ascertain that it is a spur from the Taconic range, which parts from it in Egremont; although at its southern part, it is so low that it might perhaps be regarded as an insulated range. In its northern part, this range is called Lenox mountain: opposite to Stockbridge, it is called Stockbridge mountain: and where it attains its highest elevation, in the north part of Alford, and south part of West Stockbridge, it is denominated Tom Ball. Though from various parts of this range we have a delightful view, as for instance when we descend the western slope on the road from Lenox to West Stockbridge; and more especially when from the mountain northwest of the village, we look southeasterly towards Lenox; yet Tom Ball, being the highest point, affords the most extensive prospect. On the north and northeast we have Pittsfield and Lenox: on the east, Stockbridge: on the south, the giant mountains of Mount Washington; and on the west, the Taconic and the distant Catskills. But in order to enjoy these and a multitude of other objects, checkering the vast area around you, it is necessary that the axe should do its office, until the summit is cleared: and it is desirable also that some more facile ascent should be sought than the steep and entangled one over which I urged my way. Since, however, some years ago, on a fourth of July, a cannon was drawn to the summit, I infer that a better path than I found does now exist.

Near the center of West Stockbridge is an insulated eminence, several hundred feet high, whose top I have not visited; and therefore do not attempt to describe. But I doubt not the prospect must be delightful. I make the same remark in respect to Rattle Snake-Hill, in the northeast part of Stockbridge; which can hardly fail in the midst of such a valley, to furnish the lover of scenery with a rich entertainment from its summit.

Beartown Mountain.

The vast pile of mountains that bears this frightful name, lies southeast of Stockbridge, south of Lee, and northeast of Great Barrington. Its elevation is nearly equal to that of the other commanding mountains of Berkshire; but its sides are much less precipitous, its top is more rounded, and

no prominent peaks shoot up above the general surface to form a resting place for the eye from the valley below, and for the feet of the wanderer, who loves to gaze on the glories of Berkshire scenery from all its mountains. Did such points exist, to give an interest to this mountain, I should not have hesitated to propose some more appropriate name than it bears.

Alum Hill, South Mountain and East Mountain.

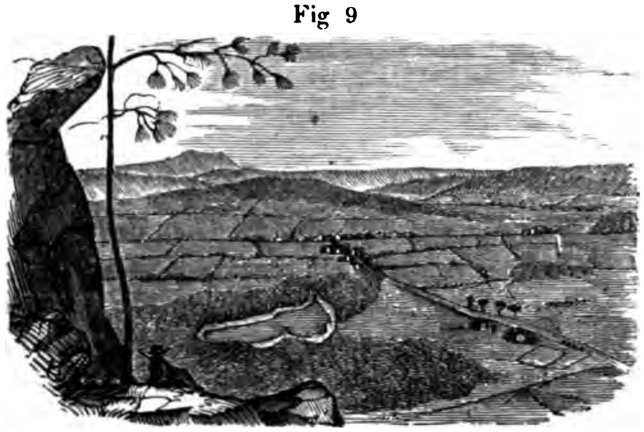
The range of hills thus denominated, may be considered perhaps as a continuation of the Beartown mountains; though in a good measure separated from them by a narrow valley. This range is also more easterly than the Beartown *pile;* for one can hardly say that the latter has any particular *range.* The former extends along the east side of the Housatonic from Great Barrington to Sheffield, and rises in some places to the height of 1600 feet above the valley. Its northern part in Great Barrington, is called Alum Hill; in the south part of that town it is sometimes called South Mountain; and its southern part in Sheffield, goes by the name of East or Northeast Mountain. Being precipitous on the west side, many points of its top furnish fine prospects; and there is another object of scenographical interest here, which I shall describe in another place. The valley of the Housatonic, with its beautiful villages, and the lofty hills of Mount Washington, are the principal objects that arrest the attention from this ridge.

Monument Mountain.

A little north east of the village of Great Barrington, the ridge of hills above described comes to an abrupt termination. But on proceeding northerly, it soon re-appears; and in the north part of the town, and in the south part of Stockbridge, forms the imposing ridge known by the name of Monument Mountain, from the fact that a pile of stones is found at its southern extremity, supposed to be the work of the aboriginees, to celebrate some event in their history. It does not rise more than 500 feet above the plain, and 1250 above tide water; but its eastern side is an almost perpendicular wall of white granular quartz; and shooting out boldly as it does into the heart of a beautiful country, the prospect from its summit is delightful. Perhaps the view northerly is most striking. There the sunny village of Stockbridge, and that of Curtisville in the same town, are in distinct view; with at least two ponds of water, and mountain beyond mountain forming the distant outline. Among the latter, Saddle mountain is distinctly visible; and even some part of the Green mountains. On the east, lie the Beartown mountains; on the south, the delightful village of Great Barrington, with Alum Hill on the left, and the grand outlines of Mount Washington on the right richly fill up that quarter; while on the west, the blue Catskill are

seen over a depression in the Taconic range. Fig. 9, will convey some idea of the northerly prospect from this spot.

Fig 9



View from Monument Mountain.

At the eastern base of this mountain the principal road from Stockbridge to Great Barrington passes; and it is possible to climb to the top directly from this road. But the usual route passes around the south end of the mountain, and ascends upon its backside. In going up the eastern side, we must clamber over a vast quantity of huge blocks, which frost and time have detached from the impending precipice above. In several places frowning masses are still left projecting from the cliff, more than 200 feet above the base, still holding on to the parent rock with apparent firmness. And it is an interesting trial of the nerves, to creep to the edge of these jutting masses, and to look down upon the fragments some hundreds of feet below. This is a feat which not every man is able to perform. For he sees fissures in every direction around the projecting masses; and there is evidence in the numberless fragments beneath, that just such masses have fallen in a thousand instances; and the thought cannot but occur, that perhaps the one on which he is now venturing himself, may be just in that state when it needs only his additional weight to precipitate it to the yawning bottom. He, however, who loves the exhilaration of looking over such a precipice, will try to dismiss this imagination and will not be satisfied until the feat is done. Yet even when the fear of falling is overcome, the head begins to grow dizzy; and the man starts back with the exclamation,

> "How dreadful
> And dizzy 'tis to cast one's eyes so low,
> ——————I'll look no more,
> Lest my brain turn."———

Near the highest part of this cliff, a pointed mass of the rock, only a few feet in diameter, has been parted at the top from the mountain: but its base not giving way, it now stands insulated and from 50 to 100 feet high. It

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goes by the name of Pulpit Rock: But I should judge that no one could climb to its top. As one ascends along the edge of the precipice, a few rods south of this rock, it looms up so finely against the northern horizon, and the landscape moreover in that direction is so fine, that I have given a sketch of it in Plate I.

Mount Everett, (Ball or Bald Mountain,) in Mount Washington.

As the traveller passes down the valley of the Housatonic through Sheffield, he cannot but observe a few miles to the right, a mountain of imposing form and height. This lies in the township of Mount Washington, or rather in connection with the Taconic mountain, it constitutes the township: the whole of it being in fact nothing but a mountain. Hence it is that the mountain in its eastern part is often confounded with the township. Within the town itself, I have heard the name of Ball, or Bald Mountain, applied to this eminence: but in the neighboring towns, this name I believe is rarely given. And were this its common designation, I cannot but believe that all the inhabitants of that portion of the State would gladly substitute some other good name. For I have already described two mountains by the name of Ball or Bald Mountain, in the county; and *Tom Ball* makes a third. And besides, who is willing that so splendid a mountain as this, should bear so untasteful a name. In many respects this mountain is the finest in Massachusetts. Its height is rather more than 2600 feet. It lies, moreover, in a portion of the State interesting not only by the intelligence and refinement of its inhabitants, but by historical associations. It deserves, therefore, a name that will connect it with the literature and history of Massachusetts. Such a name I trust all without distinction of political party, (from which I desire to stand entirely aloof,) will acknowledge that of our present Chief Magistrate to be. I cannot, therefore, but hope that the proposal which I make to denominate this eminence *Mount Everett*, may meet with the approbation and support of my fellow citizens.

It is surprising how little is known of Mount Washington, and especially of its scenery, in other parts of Massachusetts. I doubt whether nine out of ten of our intelligent citizens, beyond Berkshire County, are not ignorant of the existence of such a township within our limits. And even in the vicinity, very few have ever heard of scenery in that place, which would almost repay a lover of nature for a voyage across the Atlantic. I shall confine myself in this place to a general description of the township, with its principal mountains.

The best and almost the only way of getting into Mount Washington from Massachusetts, is through Egremont. Passing up along a vast uncultivated

slope to the height of nearly 2000 feet, you at length reach the broad valley where the few scattered inhabitants of the town reside:

> "A lowly vale, and yet uplifted high
> Among the mountains; even as if the spot
> Had been from eldest time by wish of theirs,
> So placed, to be shut out from all the world."

The western side of this valley is formed by the Taconic ridge, which, towards the Connecticut line, must rise nearly 1000 feet above the valley: and there it takes the name of Alender Mountain. Of course the prospect from its top must be very extensive in the States of New York, Connecticut, and Massachusetts. But there is no particular part of the mountain that calls for specific description.

On the east side of this valley, rises Mount Everett. Its central part is a somewhat conical, almost naked eminence; except that numerous yellow pines, two or three feet high, and whortleberry bushes, have fixed themselves wherever the crevices of the rock afford sufficient soil. Hence the view from the summit is entirely unobstructed. And what a view!

> "In depth, in height, in circuit, how serene
> The spectacle, how pure!—Of Nature's works
> In earth and air,———
> A revelation infinite it seems."

You feel yourself to be standing above every thing around you; and feel the proud consciousness of literally looking down upon all terrestrial scenes. Before you on the east, the valley through which the Housatonic meanders, stretches far northward in Massachusetts, and Southward into Connecticut; sprinkled over with copse and glebe, with small sheets of water, and beautiful villages. To the southeast especially, a large sheet of water appears, I believe in Canaan, of surpassing beauty. In the southwest, the gigantic Alender, Riga, and other mountains more remote, seem to bear the blue heavens on their heads in calm majesty; while stretching across the far distant west, the Catskills hang like the curtains of the sky. O what a glorious display of mountains all around you! and how does one in such a spot turn round and round, and drink in new glories, and feel his heart swelling more and more with emotions of sublimity, until the tired optic nerve shrinks from its office.

> "Ah that such beauty, varying in the light
> Of living nature, cannot be portrayed
> By words, nor by the pencil's silent skill,
> But is the property of him alone
> Who hath beheld it, noted it with care
> And in his mind recorded it with love."

This certainly is the grandest prospect in Massachusetts: though others are more beautiful. And the first hour that one spends in such a spot is among the richest treasures that memory lays up in her storehouse.

The evidence which the geologist perceives upon this mountain, and indeed upon nearly every other in Berkshire, that has been described, of former mighty revolutions, greatly enhances his pleasure. The description of these, however, is more appropriate to a subsequent part of my report. Suffice it to say, that he finds decided proof here, that these mountains at no very remote period, have been covered and swept over by powerful currents of water, that have in a great measure brought them into their present form: and that at a period still more remote, they have been lifted up and tossed over in a surprising manner.

Hilly Region between the top of Hoosac Mountain and Connecticut River.

The valleys in this broad tract, usually run nearly north and south; intersected however, by others crossing these in various directions. The great depth of these valleys, and the irregularity of the intervening hills, produce a multitude of most interesting prospects; which are unnoticed by the inhabi tants themselves, only because they are so common. Very different will be the feelings of one who goes thither from long confinement in the crowded city, or from the monotonous scenery of a level country.

It is extremly exhilarating to the spirits of the tasteful traveller, as he traverses these regions, especially in summer, to find such a constant variety of landscape attending every change of place. For every new hill that he climbs, he is rewarded by the discovery of some new grouping of the distant mountains; some new peak or ridge rising fantastically in the horizon; some new village crowning the distant hill with its neat white houses and church spire; or some hitherto unseen valley opens before him, through which tumbles the mountain torrent; while the vast slopes of the valley present so much diversity, softness, and richness of foliage, as to form a lovely resting place for the eye.

In such mountainous regions it was natural for the first settlers to select elevated situations for a residence. Hence in many instances the tops of these ridges are crowned with many pleasant villages. Among those which are thus situated and afford the most romantic prospects, may be named Blanford, Granville, Tolland, Chester, Middlefield, Peru, Windsor, Chesterfield, Goshen, Cummington, Plainfield, Ashfield, Hawley, Shelburne, Rowe, Heath, and Leyden. To one accustomed to reside in a valley, it is interesting to witness in one of these places, the setting, but more particularly the rising of the sun: when very probably he will see a dense fog resting upon the valleys below, and shutting out the sun, while it shines in all its glory upon the hills around the observer. Sometimes this phenomenon occurs in winter.

"'Tis morn: with gold the verdant mountain glows;
More high the snowy peaks with hues of rose.
Far stretched beneath the many tinted hills
A mighty waste of mist the valley fills;
A solemn sea! whose vales and mountains round
Stand motionless to awful silence bound:
Like leaning masts of stranded ships appear
The pines that near the coast their summit rear.
Of cabins, woods, and lawns, a pleasant shore,
Bound calm and clear the chaos still and hoar.
Loud through that midway gulf ascending, sound
Unumbered streams, with hollow roar profound;
Mount through the nearer mist, the chant of birds,
And talking voices and the low of herds;
The bark of dogs, the drowsy tinkling bell,
And wild wood mountain lutes of saddest swell."

In the elevated region east of Connecticut river, a still larger number of villages have been built upon heights commanding wide horizons: and some of these, being in a superior style of architecture, are most attractive objects to the distant traveller. What for instance can be a finer object, than the beautiful village of Leicester, seen at a distance of six or eight miles! or than Shrewsbury, Grafton, Charlton or Rutland! Similarly situated are Dudley, Sutton, Mendon, Hopkinton, Spencer, New Braintree, Hardwick, Barre, Petersham, Shutesbury, New Salem, Templeton, Winchendon, Princeton, Westford, Andover, &c. The extent and beauty of the summer prospect from the last mentioned place have long been the admiration of the traveller.

Mount Holyoke.

We come now to the valley of the Connecticut, where is some of the boldest and most beautiful scenery in the State. Mount Holyoke in Hadley claims the first notice; not on account of its superior altitude, for it is only 830 feet above the Connecticut at its base, and about 900 above Boston Harbor: but on account of its peculiar position in respect to interesting objects around. It is a part of a mountain ridge of greenstone, commencing with West Rock, near New Haven, and proceeding northerly, interrupted only by occasional valleys, across the whole of Connecticut, until it enters Massachusetts between West Springfield and Southwick, and proceeds along the west line of the first named place, and along the east line of Westfield, Easthampton, and Northampton, to the banks of the Connecticut. Until it reaches Easthampton, its elevation is small. But there it suddenly mounts up to the height of nearly a thousand feet, and forms Mount Tom. The ridge crosses the Connecticut, in a northeast direction, and curving still more to the east, passes along the dividing line of Amherst and South Hadley, until it terminates ten miles from the river in the northwest part of Belchertown. All that part of the ridge east of the river, is called Holyoke: though the

prospect house is erected near its southwestern extremity, opposite Northampton, and near the Connecticut. And that is undoubtedly the most commanding spot on the mountain, though several distinct summits, that have as yet received no uniform name, afford delightful prospects. It is not generally known, indeed, how a slight change of situation upon a mountain, will often put an almost entirely new aspect upon the surrounding scenery: Or how rather,

> "Change of place
> From kindred features diversely combin'd
> Produces change of beauty ever new."

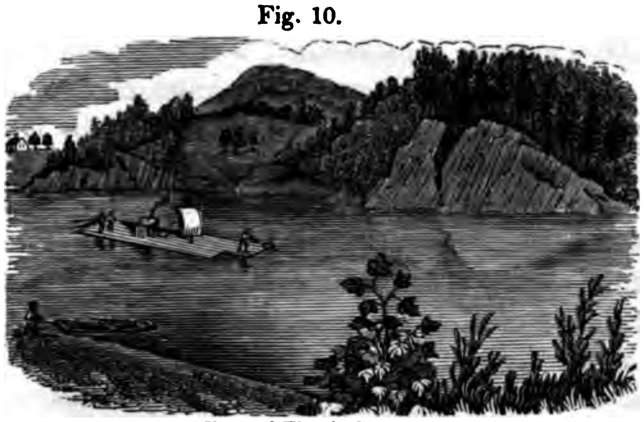
A knowledge of this fact, might often give a tenfold duration to the pleasure of the observer. The man who means to feast to the full upon mountain scenery, should be accoutred in such a manner that he can turn aside from the beaten track, urge his way through the tangled thicket, and climb the craggy cliff. There is a peculiar pleasure, which such a man only can experience, in feeling that he has reached a point perhaps never trodden by human foot, and is the first of the rational creation that ever feasted on the landscape before him.

In the view from Holyoke we have the grand and the beautiful united; the latter, however, greatly predominating. The observer finds himself lifted up nearly a thousand feet from the midst of a plain, which, northerly and southerly, is of great extent; and so comparatively narrow is the naked rock on which he stands, that he wonders why the winds and storms of centuries have not broken it down. He soon, however, forgets the mountain beneath him, in the absorbing beauties before him. For it is not a barren unenlivened plain on which his eye rests: but a rich alluvial valley, geometrically diversified in the summer with grass, corn, grain, and whatever else laborious industry has there reared. On the west, and a little elevated above the general level, the eye turns with delight to the populous village of Northampton; exhibiting in its public edifices, and private dwellings an unusual degree of neatness and elegance. A little more to the right, the quiet and substantial villages of Hadley and Hatfield, and still farther east and more distant, Amherst with its College, Gymnasium, and Academy, on a commanding eminence, form pleasant resting places for the eye. But the object that perhaps most of all arrests the attention of a man of taste, is the Connecticut, winding its way majestically, yet most beautifully, through the meadows of Hatfield, Hadley, and Northampton; and directly in front of Holyoke, as if it loved to linger in so tranquil a spot, it sweeps around in a graceful curve of three miles extent, without advancing in its oceanward course a hundred rods.* Then it passes directly through the deep opening between Holyoke

* Alas! as if indignant at this personification, the river during the floods of last spring (1840,) has cut across the neck of this peninsula! It still continues, however, to pass around the curve, as well as through the new channel: and for several years we may hope that the beauty of the spot will not be at all impaired.

mountain, as it rapidly descends to the river, we find it terminating with a naked rock extending several rods into the river, and nearly perpendicular on the side next to the water, from 20 to 100 feet high. A considerable part of this naked rock exhibits a columnar structure: not in general very perfect yet sufficiently regular to require little aid from the imagination, to be regarded as artificial; though obviously demanding giant strength for its construction. I have said that the columnar structure was not in general very perfect. But if one can work his way along the western face of this precipice at low water, he will find, near where the rock passes under the river, the tops of numerous columns of great regularity; their upper portions having been removed by the force of the stream, which for so many centuries has been battering this cliff with logs and ice. By referring to the next part of my Report, a more definite idea can be obtained of these columns. But from what I have now said, every intelligent man will perceive that they are very similar to those on the coast of Ireland, which form *Fingal's Cave* and the *Giant's Causeway.* The nature of the rock too, is essentially the same in all these places. Why then may I not be permitted to denominate this rock, *Titan's Pier?* At least, may I not hope by this description to attract the attention of visitors to Holyoke, to this spot? Hitherto it has been passed unnoticed. Fig. 10, is a view of Titan's Pier, with Holyoke in the back ground, as seen from the opposite side of the river.

Fig. 10.



View of Titan's Pier.

Titan's Piazzi.

Less than half a mile south of the point where the road that leads to the Prospect House on Holyoke strikes against the steep part of the mountain, and turn northerly, may be found an interesting and unique example of greenstone columns. After climbing up some 50 feet over the loose angular fragments, that have fallen from these columns, by the action of frost and gravity, and which form a talus whose slope is nearly 40,° the observer finds himself standing underneath a projecting mass of columns, whose lower ex-

By passing a few rods northerly from the spot above exhibited, we come to another example of projecting columns, or rather to the other end of the Piazza; and though essentially like the southern part, yet being much more elevated, and the overhanging extremities more perfect in their form, it makes an agreeable variety for the observer. Fig. 13, is a sketch taken at this spot.

Fig. 13.

Titan's Piazza.

While the summit of Holyoke attracts crowds of visiters, but very few I have reason to believe go to this Piazza: yet I have never known any one visit it who was not highly gratified. Indeed, how can one, who has any taste for Nature in her most curious aspects, remain uninterested as he stands there

"Gazing, and takes into his mind and heart,
With undistracted reverence, the effect
Of those proportions, where the Almighty hand
That made the worlds, the Sovereign Architect,
Has deigned to work as if by human art."

Mount Tom.

As this is higher than Holyoke, and insulated in the same great valley, the view from its summit cannot but be commanding; yet most of the interesting group of objects around the base of the former, is wanting around the

the latter. Hence Tom is not much frequented; while during the summer months, Holyoke is a place of great resort.

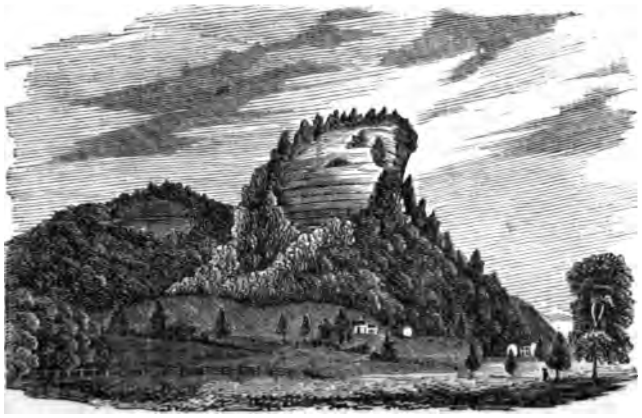
I obtained from this mountain one summer morning, a striking view, while yet the whole valley of the Connecticut was enveloped in fog, and Tom with a few other elevated peaks connected with the greenstone range, alone rose above the vapor. The sun shining brightly and the wind gently blowing, gave to this fog a strong resemblance to an agitated ocean. To the north and south it seemed illimitable; but on the east and the west, the high mountain ranges that form the boundaries of the valley of the Connecticut, constituted its shores. I could not but feel transported back to that remote period, when this great valley was enveloped in like manner by water, and Holyoke and Tom formed only low and picturesque islands upon its surface.

Sugar Loaf Mountain.

No object in the valley of the Connecticut, is more picturesque than this conical peak of red sandstone, which rises almost perpendicularly 500 feet above the plain, on the bank of the Connecticut, in the south part of Deerfield. As the traveler approaches this hill from the south, it seems as if it summit was inaccessible. But it can be attained without difficulty on foot, and affords a delightful view on almost every side. The Connecticut and the peaceful village of Sunderland on its bank, appear so near, that one imagines he might almost reach them by a single leap.

This mountain overlooks the site of some of the most sanguinary scenes that occurred during the early settlement of this region. A little south of the mountain the Indians were defeated in 1675 by Captains Lathrop and Beers: and one mile northwest, where the village of Bloody Brook now stands, (which derived its name from the circumstance,) in the same year, Captain Lathrop was drawn into an ambuscade, with a company of "eighty young men, the very flower of Essex County," who were nearly all destroyed.

Fig. 14.



Northern View of Sugar Loaf.

Deerfield Mountain.

A sandstone ridge commences at Sugar Loaf, and runs northerly through Deerfield and Greenfield, into Gill, increasing in height as far as the village of Deerfield, where it is 700 feet above the plain on which that village stands. Standing near this point, on the western edge of the mountain, a most enchanting panorama opens to view. The alluvial plain on which Deerfield, stands is sunk nearly 100 feet below the general level of the Connecticut valley; and at the southwest part of this basin, Deerfield river is seen emerging from the mountains, and winding in the most graceful curves along its whole western border. Still more beneath the eye is the village, remarkable for regularity, and for the number and size of the trees along the principal street. The meadows, a little beyond, are one of the most verdant and fertile spots in New England. Upon the whole, this view is one of the most perfect pictures of rural peace and happiness that can be imagined.

A few miles north of Deerfield and in the same valley, but on higher ground, can be seen the lovely village of Greenfield. As we approach this place from the south, the view is really one of the most enchanting in the state.

> "How gay the habitations that bedeck
> This fertile valley! Not a house but seems
> To give assurance of content within;
> Embosomed happiness and placid love;
> As if the sunshine of the day were met
> By answering brightness in the hearts of all,
> Who walk this favored ground."

Mount Toby.

This mountain of sandstone lies in the north part of Sunderland, and west part of Leverett, and is separated from Sugar Loaf and Deerfield Mountain by Connecticut river. A valley also separates it from the primitive region on the east; so that it stands there, an immense pile of irregular shape, indented by several valleys and mostly covered by forests. On various parts of the mountain interesting views may be obtained: but at the southern extremity of the highest ridge, a finer view of the valley of the Connecticut is obtained than can be got from any other eminence. Elevated above the river nearly 1000 feet, and but a little distance from it, its meanderings lie directly before you: and the villages that line its banks—Sunderland, Hadley, Hatfield, Northampton, and Amherst, appear like so many sparkling gems in its crown. It is a pity that as yet one is obliged to climb a tree in order to enjoy this fine prospect. Indeed, the spot is unknown to most:

but were the trees cleared away, and a convenient path opened, I am sure it must become a place of no little resort.

It has frequently been stated, and that too by very respectable authority, that the ridges forming East and West Rock, Holyoke, Toby, &c., are a part of the broad ranges, which, commencing at Long Island Sound, rise gradually towards the north into the Hoosac and Green Mountains on the west side of Connecticut river, and into Monadnoc and the White Mountains on the east side. But a slight knowledge of the geological character of these mountains, is sufficient to show, that the trap and conglomerate ridges along the Connecticut, differ, *toto cœlo*, from the primary ranges on either side. And a slight examination of the topography of these mountains, shows that the former are uniformly separated by deep valleys from the latter, and have no geographical connection except proximity.

What a pity it is, that so many of the most interesting mountains and hills in Massachusetts have got attached to them such uncouth and vulgar names! How must the poets lines

——————scramble up and down
On disproportioned legs, like Kangaroo,

if such words as Saddle Mountain, Rattle Snake Hill, Bear Town Mountain, Mount Tom, Mount Toby, Sugar Loaf, Blue Mountain, and Deerfield Mountain, be introduced. Holyoke, Taconic, Hoosac and Wachusett, are more tolerable; though most of them have an Indian origin. It would have been fortunate, if our forefathers had not attempted in general to supersede the aboriginal designations. For what mountain can ever become an object of much regard and attachment, if its beauties and sublimities cannot be introduced into a nation's poetry, without producing the most ridiculous associations! Fortunately there are some summits in the State yet unnamed. It is to be hoped that men of taste, will see to it, that neither Tom, nor Toby, nor Bears, nor Rattle Snakes, nor Sugar Loaves, shall be *Saddled* upon them.

Mount Warner.

I mention this hill of only 200 or 300 feet in height, on account of the rich view which is seen from its top, of that portion of the valley of the Connecticut just described. It lies in the north part of Hadley, not more than a half a mile from the river, and only two miles from Amherst; and its top can be easily reached by a carriage. A visit to it can, therefore, be performed by the invalid; and will form no mean substitute for an excursion to Holyoke or Toby.

Wachusett.

This mountain is in Princeton, whose general elevation, above the ocean, is 1100 feet: and the mountain lifts its conical head 1900 feet higher, so as to be 3000 feet above Massachusetts Bay. The ascent on foot is not difficult. From the summit, which is little more than naked rock, the eye takes in a vast extent of country on every side. On the east and south, the distant hills are comparatively low, and seem to possess an even outline. On the west and northwest, mountain ridges and peaks succeed one another, becoming more and more faint, until the distant Hoosac and Green Mountains fade away into the blue heavens. Several neat villages around the base of this mountain, with numerous ponds of considerable extent, give an interesting variety and liveliness to the picture. Probably more of Massachusetts may be seen from this mountain than from any other in the State. It attracts numerous visitors, and a small square wooden tower has been erected on the top: but it is now in ruins.

One of the most impressive circumstances in such a spot, if the air be clear and the winds at rest, is the serene quiet which there reigns: a state of nature that greatly heightens the sublimity of the scene.

"How still! no irreligious sound or sight
Rouses the soul from her severe delight,
An idle voice the sabbath region fills
Of Deep that calls to Deep across the hills."

Mount Grace.

Along the northern part of the state, between Connecticut and Merrimack rivers, are numerous high hills which afford prospects from their summits more or less interesting. But the most striking elevation is Mount Grace, a little northwest of the center of Warwick. Rising in an abrupt manner several hundred feet above the general level, (which is itself a very high one,) it affords a wide range of vision, embracing many objects of interest. Among these are Wachusett, just described, and still nearer, Monadnoc, within the limits of New Hampshire.

Blue Hills.

This is the highest and most conspicuous range of hills in the vicinity of Boston. It is most elevated at its western extremity, in the southwest part of Milton, where it rises 710 feet above the ocean. A little to the southeast, and just within the limits of Quincy, the summit is elevated 680 feet. Still

farther east, it is 570 feet. Northeast a little from this peak, is another 530 feet high. The Monument Quarry in the northeast part of these hills, is 390 feet high; and Pine Hill, to the southeast of this quarry, is 235 feet high. All these summits command extensive and most interesting prospects. And there are some circumstances that impart to these landscapes peculiar interest. One is the proximity of these hills to Boston; whose numerous edifices, masts, spires, and towers, and, nobly peering above the rest, the dome of the State House, present before the observer, a most forcible example of human skill and industry, vieing with, and almost eclipsing nature. And the high state of cultivation exhibited in the vicinity of Boston, with the numerous elegant mansions of private gentlemen, crowning almost every hill, and imparting an air of freshness and animation to the valley and the plain, testify how much taste and wealth can do in giving new charms to the face of nature.

From these hills the observer has also a fine view of Boston Harbor; and this is another circumstance of peculiar interest. For to look out upon the ocean is always an imposing sight; but when that ocean is studded with islands, most picturesque in shape and position, and the frequent sail is seen gliding among them, he must be insensible indeed, whose soul does not kindle at the scene, and linger upon it with delight.

On Monument Hill, is opened perhaps the largest of the quarries of Quincy granite; and from thence a rail road runs directly to Neponset river: and this is another circumstance of peculiar interest to the visitor of these hills. Let him ascend the granite tower, which the proprietors of the quarry have erected on its site, and he will have before him, not merely the rich variety of natural and artificial objects above described, but this railway, also, stretching away for miles in a right line towards the river, with here and there the cars going and returning. Such conveyances, however, have ceased to be a novelty in Massachusetts.

Many other hills of moderate altitude around Boston, particularly on the south of the city, might be mentioned as worthy of a visit for the prospects presented from their summits. The heights of the following are given on Hale's beautiful "Map of Boston and its vicinity."

In Quincy, near the Common,		210 feet.
do.	One mile north,	175
do.	A half mile farther north,	107
do.	A little N. W. of Hon. J. Quincy's seat,	40
do.	Great Hill, near the eastern extremity of the town,	94
do.	Squantum,	99
In Braintree, near the east line,		205
In Weymouth, near the west line,		210

In Plymouth, Near Town River Bay,	- -	134 feet.
In Hingham, N. W. part of the town,	- -	112
do. On Crown Point,	- - -	102
do. A little N. W. of Mr. Brook's M. House,	-	107
In Hingham, a little south of Mr. Brook's M. House,	-	75
do. Near the east line of the town,	- -	230
In Cohasset, near the west line of the town,	- -	215
do. A mile south of Nantasket Beach,	-	175
do. N. E. part of the town, close to the shore,	-	110
In Milton, at the Academy,	- - - - -	208
do. One mile south of this place,	- -	226
do. A mile west of the last,	- - -	217
do. N. W. part of the town,	- - -	216
In Dedham, at Mr. White's M. House,	- -	405
In Dover, Pine Hill, south part,	- - -	400
In Waltham, Prospect Hill,	- - - -	470
do. Bear Hill,	- - - -	510
do. Near the N. E. line of the town,	- -	570
In Lincoln, Dr. Stearns' M. House,	- - -	470
do. Mount Tabor,	- - - -	370
In West Cambridge, near the S. W. line of the town,	-	320
In Watertown, N. W. corner,	- - - -	310
In Charlestown, Prospect Hill,	- - -	120
do Winter Hill,	- - - -	120
In Chelsea, Pulling Point,	- - - -	84
In Lynn, near Phillip's Point,	- - -	135
do. Near King's Beach,	- - -	147
do. A mile N. E. of Lynn Hotel,	- -	120
do. Half a mile north of "	- -	125
do. A mile north of " "	- -	140
In Marblehead, Legg's Hill,	- - - -	160
do. Half a mile N. E. from do.	- -	97
do. Three quarters of a mile N. E. of the last,		105
do. N. E. part of the town,	- - -	135
do. A little north of the village,	- -	130
In Marblehead, on Marblehead Neck,	- -	137
In Salem, east of Spring Pond,	- - -	197
do. N. W. part of the town,	- - -	145
do. S. E. part of the town,	- - -	175
do. A little west of South Fields,	- -	186

Some of the views from the hills around Salem, and those on the promon-

tory of Marblehead, are of an imposing character. The extreme rockiness of the coast and islands, strikes the observer at first, as evidence of irreclaimable sterility. But when he sees the luxuriant vegetation of every cultivated spot, and the populousness and elegance of Salem and many of the neighboring villages, the contrast increases his pleasure.

Having thus noticed all the important hills and mountains in the State, with reference to views from their summits, I proceed briefly to sketch the picturesque scenery of particular districts. For we have not seen all that is interesting in the scenery of a country, when we have only looked over it from its elevated points. The ever varying prospects which are produced by those elevations, to one winding through the valleys among them, are often of the most romantic character.

The Valleys of Berkshire.

In exemplification of this position, let us suppose an observer to pass from Williamstown southerly through New Ashford, Lanesborough, Lenox, Lee, Stockbridge, Great Barrington, and Sheffield. Till beyond New Ashford, he will be following one of the branches of the Hoosac river up the valley of Williamstown. On his right rises the broad slope of the Taconic range of mountains; while on his left, and near at hand, Saddle Mountain shoots up in imposing grandeur; and more distant, through a lateral valley, a part of the Hoosac range is visible. If it be spring, these mountain sides exhibit numerous species of trees and shrubs, emulating one another in putting on their parti-colored foliage; while here and there an Aronia, or a Cornus, is entirely clothed with white blossoms before the appearance of its leaves. If it be summer, these vast slopes are covered from base to summit with a vegetable dress, embracing every hue of green, from the dark hemlock and pine, to the almost silvery whiteness of the white oak and poplar. If it be autumn, that same foliage, now assuming almost every color of the spectrum, and of hues almost as bright, presents one of the most splendid objects in nature.

As the traveler approaches New Ashford, the hills crowd closer and closer upon his path, which winds among them in conformity with the sinuosities of the river: and a succession of romantic and Alpine beauties is constantly opening before him.

Having reached the north part of Lanesborough, he begins to descend into the valley of the Housatonic, which gradually widens before him, and ere he reaches Sheffield, presents to his view a number of most delightful villages, generally in the vicinity of fertile alluvial tracts; while on every side, mountains of various altitudes and of almost every shape, form the out-

line of the landscape. Where, for instance, does the traveler meet in any part of our land with lovlier spots than Pittsfield, Lenox, Lee, Stockbridge, and Great Barrington!

Another interesting excursion in Berkshire, is to pass from Williamstown directly to Hancock. This road carries the traveler through a valley very narrow, yet walled up almost to the heavens by different ridges of the Taconic. So steep are the slopes on either hand, that cultivation is confined almost wholly to the valley. This valley opens into New York and leads to Lebanon Springs.

If in passing southerly from Williamstown, we take the left hand road, we enter the deep valley in which is situated North and South Adams, between Saddle and Hoosac Mountains. In this valley, especially in the northern part of it, one of the most curious objects that diversify the scenery, is a large number of gravelly mounds, of conical shape, which might easily be mistaken, were it not for their great size, for the work of man: but which are really the work of water: having been unquestionably produced by that diluvial agency which has essentially modified this whole region. Plate 3, exhibits several of these mounds, occurring a little west of the village of North Adams. On the left, is the northern slope of Saddle Mountain: and on the right, the southern slope of Ball Mountain: while between them at a distance, is the Taconic range. The sketch was taken a few rods west of the village, and is a northwest view.

On the east side of the valley, a little south of the village, many more of these mounds occur. Fig. 15, is a view of some of them as seen from the west, and looking directly towards Hoosac Mountain.

Fig 15.

Diluvial Hillocks: Adams.—Mrs. Hitchcock, del.

If we follow this valley southerly through Cheshire, we shall meet with much beautiful scenery; and if we turn still more to the left, and go to Dal-

ton, through the Valley Road, it will become extremely wild and romantic. In passing from Dalton to Lee, the country, though rougher, is quite striking. And from Lee to Stockbridge, it becomes highly picturesque.

The existence of numerous large ponds in almost every part of Berkshire, often called lakes, gives to her mountains and valleys a yet more romantic and enticing aspect. For it is universally admitted, that water forms a most important part of a good landscape. And a mountain or a village seen across a sheet of water, appears doubly beautiful. Fig. 16, is a distant view of Tyringham, as seen across a pond, from the road leading from Sheffield to Otis.

Fig. 16

Distant View of Tyringham.—Mrs. Hitchcock, del.

Lenox has long been celebrated for its enchanting scenery; and the beautiful ponds existing there are one of the most important constituents in its scenery. Fig. 17, is a view across what is called Smith's Pond.

Fig. 17.

Smith's Pond : Lenox.—Miss M——, del.

Fig. 18, is a distant view of Mount Everett, and other mountains in that direction, seen across Scott's Pond in Lenox.

Fig. 18.

Scott's Pond and Mts. in Mt. Washington.—Miss M——, del.

Plate 7, is a view of Stockbridge Pond, in the north part of the town, with the surrounding scenery; and will give a good idea of this kind of landscape in Berkshire.

Some sketches have been given of diluvial elevations in the north part of Berkshire. The same phenomenon is also met with in other parts of the county. The following sketch (Fig. 19.) exhibits them at the eastern base of Monument Mountain.

Fig. 19.

Diluvial Hillocks: Monument Mt.—Mrs. Hitchcock, del.

Valley of the Connecticut.

The circumstances that render the scenery of this valley so attractive to the man of taste, are the extent and fertility of its alluvial meadows; the precipitous boldness and irregular outline of its trap and sandstone ranges, already described; and the magnitude and beauty of the Connecticut, and of its principal tributaries, the Westfield and the Deerfield, winding through the secondary basins, which their waters or other agencies have produced.

Let such a region as this be sprinkled over with villages like Longmeadow, Springfield, West Springfield, South Hadley, Amherst, Sunderland, Northampton, Hadley, Hatfield, Deerfield, Greenfield, and Northfield, and it needs the inspiration of poetry to describe its beauties. Unfortunately, however, the valley of the Connecticut remains yet to be described.

Several of the villages above named are sufficiently elevated to overlook the surrounding region to a considerable extent, though neighboring mountains still tower above them; and thus are combined the beauties and advantages of a location upon a hill, with those to be found in a valley. The upper terrace of Springfield, on which stands the United States Armory, is thus elevated. Still higher is South Hadley, with Holyoke and Tom half encircling it on the west and north, except where the Connecticut has opened a passage between these mountains; serving as a vista through which is disclosed at greater distance the Hoosac range; and from the hill near Mount Holyoke Female Seminary in that place, is a landscape that will suffer by comparison with few others. From the Gymnasium on Round Hill in Northampton, is one of the richest views of fertile meadows, and mountains of fantastic shape, to be found in the country. From the Gymnasium at Amherst, is a similar prospect: and from the College tower in the same place, one of wider range and more imposing features. From the Female Seminary in Greenfield, a southern prospect opens of enchanting beauty.

The opening of a new road along the banks of the Connecticut, in the northwest part of South Hadley, has brought to light (I mean, to my own eyes,) a most lovely landscape. Standing on the elevated bank and facing the northwest, you look directly up the Connecticut river, where it passes between Holyoke and Tom; those mountains rising with precipitous boldness on either side of the valley. Through the opening, the river is seen for two or three miles, enlivened by one or two lovely islands, while over the rich meadows that constitute the banks, are scattered trees, through which, half hidden, appears in the distance the village of Northampton; its more conspicuous edifices only being visible. Far beyond, and forming the remote outline of the picture, lies the broad eastern slope of the Hoosac mountains. (See Plate IV.)

Another road has been recently opened on the banks of the Connecticut in the north part of Springfield, a mile or two below South Hadley Canal: and here, too, as you face the northwest, a landscape full of interest opens before you. In full view towards the left hand side of the picture, you have the Falls in the Connecticut and the entrance of the Canal on the north shore. A little to the right of the Canal, a well built village occupies a beautiful ampitheatre, whose elevated border is not less than 150 feet high, and mostly crowned with oakes and pines. Beyond this, at no great distance, how-

ever, Mount Tom occupies the back ground with its bold and imposing outline.

Three miles southwest of Sugar Loaf, in Deerfield, that peak presents one of the most unique views conceivable. Its outlines are so regular, that were the traveler to meet with it in Egypt, he might, at first view, regard it as indebted to human art, for its present shape. At any rate, in that country it would probably have been wrought into a second Sphinx, or some other gigantic monster. But to the student of nature it is no less interesting as the work of God. A little to the left, as seen from the place mentioned above, the southern point of the Deerfield Mountain, sometimes called North Sugar Loaf, appears, as well as the bold western front of that range for several miles; and a little to the right, across the Connecticut, Mount Toby is in full view. The sketch, Fig. 14, was taken considerably nearer to Sugar Loaf, and differs somewhat from the above description.

A little north of Sugar Loaf, and on the eastern bank of the river, a southern view of great beauty is presented. You stand upon a ridge of rocks which forms a cliff on the river bank, a short distance beyond the village of Sunderland, and there you see the river, for a mile in length, as far as Sunderland bridge: while on the opposite side of the river, an oblique view is obtained of Sugar Loaf, and the south end of Deerfield Mountain, with a distant glimpse of the primitive range of Conway and Whately. The church in the latter place is just visible. Fig. 20, will convey some idea of this Landscape.

Fig. 20.

View down Ct. River: Sunderland.—H. J. Van Lennep, del.

In passing south from the village of Hadley towards Holyoke, just where the road comes upon the bank of the Connecticut river, an enchanting prospects opens to the south. A lovely island covered with grass and fringed with trees, is directly before you, in the direction of the Gorge between Holyoke

and Tom; the latter being upon the right, and the former upon the left. Plate 5, will give a good idea of this spot.

The peculiar features of the Holyoke range, as seen from the valley on the north side, are shown in Plate 6. Its top will be seen to be exceedingly irregular. The depressions are valleys produced by the erosive action of water, as will be more fully explained in another place; and the principal object in presenting this sketch, is to exhibit those valleys. Still, as an interesting landscape, showing some of the peculiar features of the valley of the Connecticut, it deserves a notice in this place.

Fig. 20, is a northerly view from Wolcott Hill, about a mile south of the village in Springfield. A part of that village is shown, with the river and Mount Tom in the distance. But it conveys a very inadequate idea of the beauty of this prospect.

Fig. 21.

View from Wolcot Hill: Springfield.—H. J. Van Lennep, del.

Ravine of Westfield River.

Westfield river has found or formed a deep passage across the whole eastern slope of the Hoosac range of Mountains, through the towns of Westfield, Russell, Blanford, Chester, and Middlefield. The ravine through which it passes, is for the most part very deep and narrow, and cuts across, not only the general direction of the mountain ranges, but across the rock strata also. Hence it might be expected that the sides of this ravine would exhibit wild and interesting scenery. Nor will this expectation be disappointed, if the traveler follows the Pontoosuc Turnpike through this defile. Hills and precipices of every shape will crowd upon his path, now approaching so near as to form a narrow gorge, and now gently retiring so as to leave room enough for some industrious farmer to erect his habitation, and gain a subsistence in the deeply embosomed glen. In passing through such a region,

the man destitute of taste will be heard speaking only of the roughness, sterility, and gloominess of the country; while the man of taste and sensibility will be absorbed in admiring its beauties and sublimities.

It is an interesting fact that the Western Rail Road from Springfield to Albany, passes through the whole extent of this ravine: and when it is completed, it will afford one of the most romantic trips in the country. Then, the citizen of Boston or Albany, in little more than half a day, will find himself among scenery as wild and Alpine as almost any in the state: and that too with little more fatigue than if he had been sitting in his own parlor. At one moment he will find himself between mountains so high and so close upon his path, and so steep withal, as almost to exclude the sun: and yet exhibiting all their original wildness. Next a narrow valley will open before him: and the comfortable farm house, with cultivated fields, will afford him an enticing picture of rural retirement and happiness.

> "Were this
> Man's only dwelling, sole appointed seat,
> First, last, and single, in the breathing world,
> It could not be more quiet: peace is here
> Or nowhere."

In another moment his eye will be arrested by the roaring cataract, plunging amid the jutting rocks. And then will the rocks close in upon his path, standing upon either hand in frowning attitude, and crowned by overhanging trees, which only partially hide the ragged rocks upon the vast and steep slopes. Down these slospes, at intervals, he will hear the roaring cataract descend, while all along his path, will the principal stream assume a multitude of aspects: now heard only, not seen, roaring at the bottom of some dark gorge: now showing its silvery reflections among the branches of the trees: and now moving calmly through the cultivated glen.

Such essentially will this ride be over an extent of nearly 30 miles: and when the traveler descends into the valleys of Berkshire, new and wider visions of nature await him: so that even at rail road speed, I am confident this will be one of the most interesting routes in the United States.

Ravine and Gorge of Deerfield River.

Quite as remarkable as that just described, is the gulf through which Deerfield river passes, in a southeast direction, nearly across the whole of the broad mountain range, between the Connecticut and Williamstown valleys. Perhaps the best route for visiting this ravine, is to take the turnpike road from Greenfield to Williamstown. On this road the traveler will not come upon the banks of Deerfield river, until he reaches the west part of Shelburne: but he will obtain a most delightful view of Greenfield, as he ascends the

high hills west of that place; and as to the defile, through which Deerfield river runs between Shelburne and Conway, it is so narrow, and the banks, of several hundred feet in height, are so steep, that it is difficult even on foot to find a passage: though full of romantic and sublime objects to the man who has the strength and courage to pass through it. From the west part of Shelburne, however, to the foot of the principal ridge of Hoosac mountain in Florida, a good road leads along the banks of the stream: though in a few places hard pressed between the hill and the river. In one spot it is actually sustained a hundred feet above the river, upon piles driven into the steep and naked declivity of a mountain slide. But through nearly the whole of Charlemont, the hills recede so far from the river, as to form an alluvial valley of considerable width and fertility. The loftiness of these hills, however, and the frequent openings of lateral ravines, through which the small tributaries of Deerfield river disembogue, keep the attention of the tasteful man awake. As he goes westward, these hills approach nearer and nearer to the river, become bolder in their outlines, and steeper in their declivities, till at length, in Zoar and Florida, they shoot up, sometimes a thousand feet high, in a variety of spiry and fantastic forms, and the traveler, as he looks forward, can often see no opening through which the river can find its way. The murmuring of its waters, however, at the bottom of the gulf, sometimes swelling into a roar, as they rush through some narrow defile, tell him that they have found a passage. At length the road leaves the river, and ascends tne ridge, which in the vicinity is alone denominated Hoosac Mountain, and which is here 1448 feet above the river. It is well to follow this road at least to the height of a thousand feet, in order to look back upon the wild and singular grouping of mountains, among which this river has strangely found a passage: and also to get a view of some of those vast slopes of unbroken forest, which the sides of these mountains present; and which during the twilight, are most splendid objects.

In two or three instances it has happened that I have passed along this ravine in the evening, when the moon was well above the horizon; and I can truly say, that the wildness and sublimity of the scene were thereby immensely heightened: so that I felt it to be a privilege to be thus benighted.

The bridge across Deerfield river is built in one of the wildest parts of this ravine; and having no piers, except at the extremities, it presents a singular aspect. Fig. 21, is a sketch of it with the scenery around, as seen by an observer looking down the river. The hills shown at the right and left and beyond are very precipitous and very high.

Fig. 21

View of Zoar Bridge.—Mrs. Hitchcock, del.

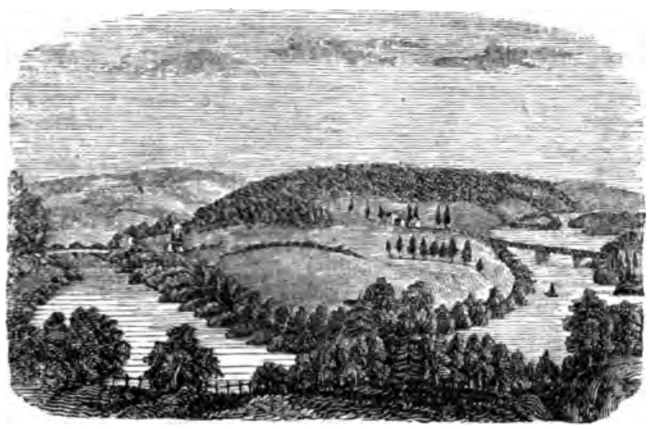
Several miles higher up Deerfield river, between Rowe and Monroe, a bridge of a similar character occupies a simular situation. At that spot there is literally no level ground on either bank: but the road down one of the longest and steepest hills in Massachusetts,* leading from Rowe to Monroe, precipitates you at once upon the bridge, and the moment you reach the opposite shore, you commence ascending a hill equally long and steep. I think the view of this bridge, as you look down the stream, is finer than that of Zoar bridge: for not more than half a mile below the bridge at the former place, and nearly in a line with the river, there rises a sharply conical mountain to the height probably of a thousand feet. But I have not been able to obtain a sketch at this spot.

Near the mouth of Deerfield River, in Deerfield, is a remarkable gorge through which that stream empties into the Connecticut. A greenstone ridge of 300 or 400 feet in height, has been cut through in some way or other, in width only sufficient to suffer the river to pass. This cut is in full view from the stage road between Deerfield and Greenfield, where it crosses Deerfield river.

Fig. 22, exhibits this gorge as seen from the eastern side of the ridge. It shows also the confluence of Deerfield and Connecticut rivers, with the romantic scenery aroun d, and bridges across each stream: that on the right being built over the Connecticut, and that on the left over the Deerfield river. The mountains seen at a distance, through the gorge, are the primitive range passing through Shelburne. This is the most northerly point of steam navigation on the Connecticut.

* Passing down this hill soon after a heavy shower in a wagon, my horse in one place, having braced his legs firmly to hold back the load, was nevertheless slid along several feet without stepping: yet this is the best road in Massachusetts that leads into Monroe.

Fig 22.



Confluence of Deerfield and Connecticut Rivers.—Mrs. Hitchcock, del.

Valley of Worcester.

Apart from human culture, this geographical center of Massachusetts would present no very striking attractions to the lover of natural scenery. But this valley possesses precisely those features which art is capable of rendering extremely fascinating. And there is scarcely to be met with, in this or any other country, a more charming landscape than Worcester presents, from almost any of the moderately elevated hills that surround it. The high state of agriculture in every part of the valley, and the fine taste and neatness exhibited in all the buildings of this flourishing town, with the great elegance of many edifices, and the intermingling of so many and fine shade and fruit trees, spread over the prospect beauty of a high order, on which the eye delights to linger. I have never seen, in a community of equal extent, so few marks of poverty and human degradation as in this valley. And it is this aspect of comfort and independence among all classes, that enhances greatly the pleasure with which every true American heart contemplates this scene; since it must be considered as exhibiting the happy influence of free institutions.

Valley of the Merrimac.

The scenery along this river is characterized by beauty rather than sublimity. The hills and mountains are rarely precipitous or very lofty: but generally of gentle ascent and capable of cultivation to their summits. The attractions of the landscape consist of a noble river, beautiful villages, and well cultivated fields and meadows. To the man who loves to see natural scenery modified by human culture, and on every side the marks of an in-

telligent and happy population, with manufacturing establishments uncommonly flourishing, a ride down this stream on either bank, cannot but be highly interesting. And when he approaches the ocean, let him enter Newburyport from the north, across the chain bridge, and he will have before him a delightful view of one of the most beautiful towns in New England. And if he wishes still farther to witness the riches of the surrounding scenery, let him ascend the tower of the fifth church in that place, and a wide scene of beauties on the land and on the sea—natural and artificial—fills the circle of his vision.

Fig. 23, and Plate 8, are sketches taken from nearly the same spot: that is, from a point about, half way between Haverhill and East Bradford, not very elevated. On the left, and up the river, Haverhill is situated; and though partially hidden, is seen from this spot to great advantage. On the right, and down the river, the quiet village and church of East Bradford are seen: or rather, only a small part of the place is seen. But enough is visible to convey a good idea of a quiet and happy village: and I am happy to say, what can rarely be said, that the traveler finds upon acquaintance that he has not mistaken its character.

Fig. 23.

View of Bradford from the West.—H. J. Van Lennep, del.

From a hill a little south of Bradford meeting house, is a prospect still more extensive than from the point above mentioned. Rev. Mr. Perry informs me, that from that hill he has counted 100 meeting houses. From a hill a little farther east, the ocean is visible.

There is an exceedingly beautiful landscape before you, as you ascend the Merrimac on its south side, and come to the R. Road Depot, half a mile south of the village of Tyngsborough. The river here makes a graceful curve, which produces an equally graceful curve in the rail road, while above both, upon the left bank, a few neatly built houses make their appearance, mingled with trees. The pencil might here be employed to advantage: but I have not been able to obtain a sketch of this spot.

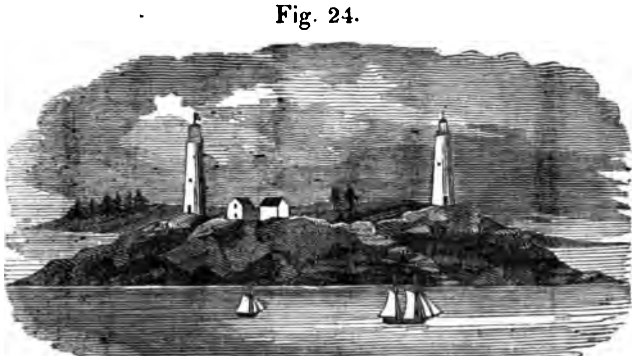
COAST SCENERY.

The connection between geology and scenery is no where more obvious than upon a coast, exposed like that of Massachusetts, to the powerful action of the waves. There you will find the headlands and promontories almost always resulting either from the occurrence of an anticlinal axis, running into the sea, directly or obliquely, or from an alternation of harder and softer rocks; or from the accumulation of sand and shingle by the action of waves and currents. No where have these agencies been more active, nor the diverse power of resistance more obvious, than along the coast of Massachusetts. In vain have the waves for thousands of years spent their fury upon the unyielding sienite of Cape Ann and Cohasset. Not so with the slaty and softer rocks of Boston Harbor: only fragments of which remain in the form of islands to attest the former continued existence of the same formations: while the sands of Cape Cod show whither the comminuted rocks have been transported.

Boston Harbor.

Let no man imagine that he has seen all that is interesting in the scenery of Massachusetts, until he has passed in various directions among the islands of Boston Harbor. Many of these islands are extremely unique in appearance, and in their varied grouping, as seen from a vessel moving onward among them, they present landscapes of the most picturesque character. Suppose a vessel to come into the harbor from the northeast. The island on which the light houses are placed, at the extremity of Cape Ann, is a striking object; chiefly because the waves have left scarcely nothing there but rock. Fig. 24, was sketched as we rushed past this island in a Steam-Boat.

Fig. 24.

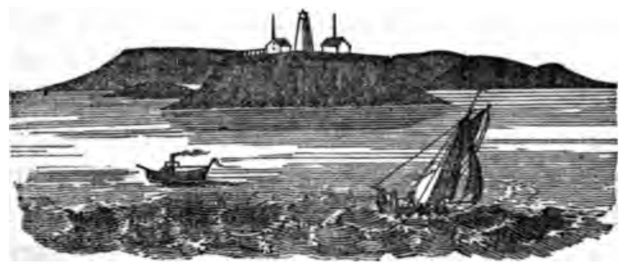


Extremity of Cape Ann: Massachusetts.—Mrs. Hitchcock, del.

As we entered the Harbor, Fig. 25 was sketched under similar circumstances as Fig. 24. I am not sure whether the islands represented are Calf

Island, the Great Brewster, &c. or Lovell's, Gallop's, &c. for during the few moments in which the work must be done, I had no one near me who was well acquainted with the harbor.

Fig. 25.



Islands in Boston Harbor.—Mrs. Hitchcock, del.

Wherever these islands are covered with sand or gravel, their eastern and northeastern sides present almost perpendicular cliffs, showing that the waves are wasting them away. This was shown strikingly in the last figure: and the same is seen in Fig. 26, which is a view of the islands as they appear on entering the Harbor through the usual channel from the southeast; or past the Light Houses and Point Alderton. Sketches of this sort might be multiplied greatly by a slight variation of the position. But the most important features have been exhibited.

Fig. 26.

Denudation of Islands in Boston Harbor.—Mrs. Hitchcock, del.

In all the views in Boston Harbor, when we look towards the city, they become doubly interesting. For a city seen from the water is usually an imposing object, when, like Boston, it slopes towards the shore, and its site is unequal. In this instance the venerable dome of the State House affords an appropriate crown for a noble city, and is visible from every part of the Harbor.

View from the State House.

Upon the whole, there is not a more magnificent prospect in Massachusetts, than that from the dome of the State House in Boston; and it will bear a

comparison, it is said, with the most celebrated views of a similar kind in Europe. This noble building stands upon Beacon Hill, the highest spot in Boston: and the lantern upon its dome is about 200 feet above the harbor. From this elevation the whole of Boston, with its wharfs, shipping, and public edifices; all the islands in its harbor; the shores of the harbor lined with villages and cultivated fields; and within a circle of ten miles, not less than twenty villages, containing, with Boston, more than 150,000 inhabitants, are here surveyed at a glance. Almost every dwelling of this numerous population, is, indeed, visible: and it is rare to see in a circle of so small extent, as many edifices so elegant; and so few that indicate extreme poverty and wretchedness. So richly cultivated is the vicinity of Boston, that it has the appearance of a vast garden. Yet we do not see here the traces of that vandal spirit, which, in so many parts of our land, is making sad havoc with our groves and shade trees; but enough have been spared or planted in this vicinity to give a refreshing and luxuriant aspect to the scenery.

The political and moral considerations which irresistibly force themselves on the mind when contemplating such a scene, cannot fail greatly to increase the pleasure of the observer. What a drawback upon that pleasure must it be, when the traveler is compelled to say, as he cannot but say, when gazing on a large proportion of the interesting scenery of the eastern continent,

'Art, glory, freedom fails, though Nature still is fair.'

On the contrary, how refreshing to the benevolent spirit, as it surveys from this eminence the dwellings of 150,000 human beings, to be assured that there is not a slave among them all; and that could the eye take in every part of the Commonwealth, it would read on every door post the inscription, 'all men are born free and equal;' a maxim which exerts a talismanic influence in defending the feeblest inmate against oppression. Nor should the observer forget, that this same maxim forms the basis of every law originating from the edifice on which he stands; and that it is not licentious liberty that is here enjoyed; but liberty guarded by law, and sustained by law: and that it is the general prevalence of knowledge and virtue in the community, that renders it possible to sustain a proper balance between liberty and law. Foreign nations may predict that our beautiful republican system will be ephemeral. It will, indeed, pass away whenever unprincipled ignorance shall be permitted to bear sway. But so long as intelligence and moral principle predominate in the community, the ark of liberty is safe. At any rate, it is certain that we do now enjoy the blessings of freedom, and the means, widely diffused, of intellectual, moral, and religious cultivation. As a consequence, contentment, competence, and happiness, are found even among the lowest classes in the community. The traveler of a benevolent heart

will rejoice to see, as he wanders over the hills and valleys of our Commonwealth, how very few in the community have not all the essential means of human happiness within their reach. He need not fear being detained for days in the wildest and most secluded parts of the State. For scarcely will he find the hut, where if really needing shelter, he will not find a welcome, and all that a temperate man needs to make him comfortable. A man who has frequently been thrown into such situations, or in other words, has had opportunity to learn the character and circumstances of the lowest as well as the highest classes in our community, will find his pleasure greatly heightened in surveying our scenery. Let us hope that succeeding travelers, through many generations, may not be deprived of this same happiness; and instead of indulging in gloomy predictions of the downfall of liberty, let every man strive to form and retain that intellectual, moral, and religious character, which is its only effectual support.

But I fear that I am wandering beyond my appropriate sphere, by these remarks. I proceed to notice some other objects worthy the attention of the man of leisure and taste.

New Bedford seen from its Harbor.

This flourishing place, already wearing the aspect of a populous city, is seen to great advantage in sailing up its harbor. As the ground on which it is built slopes towards the water, the various objects of interest are thus brought into view, rising above one another in a distinct and pleasing manner.

Narraganset and Mount Hope Bays.

An excursion from Taunton to Newport, Rhode Island, down Taunton river, and Mount Hope Bay, and especially from Providence to Newport along Narraganset Bay, conducts the traveler among scenery of great beauty and loveliness. The fertility of most of the country, the neat villages along the way, the numerous irregular contractions and expansions of these bays, forming capes, isthmuses, promontories, bays and harbors, in miniature; the islands that are occasionally interspersed, and the interesting historical associations connected with that region, conspire to keep the attention alive and to gratify the taste. Mount Hope, the granite watch tower of the celebrated Sachem Phillip, still commands a fine prospect of the surrounding region; and we see at once why that sagacious chieftain selected this place for his retreat.

The north and south shores of Massachusetts Bay present much scenery of such a sui generis or peculiar character, as to render it extremely interesting to one unaccustomed to it. As a general fact, there is so great a contrast in the appearance of the two capes which form this Bay, that a visit to the

one, only prepares the way for rendering more interesting an excursion to the other. We will suppose the traveler to start from Boston and first proceed along the north shore of the Bay.

Nahant.

He will not fail to visit Nahant; which will be the first place of peculiar interest he will meet along this coast. It is a bold rocky promontory, connected by a low sandy neck of land with Lynn: or rather, it consists of two islands connected together, and with the main land, by ridges of sand and pebbles. At low water, a perfectly smooth beach of the finest sand is laid bare, which constitutes the road from the mainland; and this sand is so firmly compacted by the perpetual beating of the waves of the Atlantic, that neither horse nor carriage make scarcely a perceptible impression. Hence the ride becomes a delightful one; and although the promontory itself has a very barren and desolate appearance, yet the singularity of the surrounding scenery, the neatness of the houses, built in a peculiar style, and the wide extent of the horizon, conspire to render the prospect during the summer of a most attractive character. It is a place of great resort in the warmer months, and a steamboat plies daily between this place and Boston. The vicinity of the spacious hotel at Nahant is very interesting to the geologist: but the particular characteristics of the rocks must be deferred to a subsequent part of this Report.

View from Saugus towards the Ocean.

A little east of the meeting house in the retired village of Saugus, is a small but singular conical eminence, from whose summit the delightful view exhibited on Plate 9, opens towards the ocean. The objects most interesting are the river, with its graceful meanders, a part of Lynn near its mouth, the ocean beyond, and the promontory of Nahant.

Cape Ann.

I have spoken of the rockiness of the coast in the vicinity of Salem. As we proceed towards Gloucester, which occupies all of what is properly called Cape Ann, the ledges multiply; and on the Cape the forests are mostly cut down, while the surface is almost literally covered, either with rocks in place, or with bowlders of every size. In the northwestern part of Gloucester particularly, the soil is almost wholly concealed by the countless number of these rounded masses. Over nearly all the Cape, indeed, sienite of every description meets the eye in immense quantities; and the traveler naturally enquires whither the soil has been carried, which must once have covered the rocks; and what mighty flood of waters could have swept over this region with the fury requisite to produce such devastation. Scenery of this kind, would be regarded as extremely dreary, were not the desolation

carried to such an extent as to be interesting by its novelty. It is scarcely possible for any man, however little interested in the *bizarre* of natural scenery, to traverse this region for the first time, without having his attention forcibly and constantly directed to the landscape around him. And hence this must be one of the best excursions for those afflicted with ennui, that can be found.

It is not rocks alone that form striking objects upon Cape Ann. For in some places these are covered by pure white sand: producing a striking contrast to the rocky cliffs and bowlders. Fig. 27 is a northerly view of Squam on the northeast part of Cape Ann; and it exhibits both kinds of scenery at one *coup d'œil.*

Fig. 27.

View of Squam in Gloucester.—H. J. Van Lennep, del.

The sketch shown in Fig. 28 was taken a little south from the spot where Fig. 27 was drawn; and on the road leading to Gloucester. It will convey an idea of the appearance of hundreds of acres in that part of Gloucester. What a complete image does it present of perfect barrenness and desolation.

"Far and near
We have an image of the pristine earth,
The planet in its nakedness."

Fig. 28.

Sketch on Cape Ann.—H. J. Van Lennep, del.

Nantasket Beach and Hull.

Suppose now the traveler, for the sake of amusement or recreation, should proceed along the south shore of Boston Harbor and Massachusetts Bay. Admiring as he passes the scenery of Dorchester, Quincy, and Hingham, the first objects that will have a peculiar claim upon his attention, are Nantasket Beach and Hull.

To say nothing of the rocks, which at the head of this beach constitute almost the entire surface, rivaling even Cape Ann in this respect, and which on the shore present a remarkable and elegant variety of colors, the beach itself, not less than four or five miles in extent, is much more interesting than that leading to Nahant. The Light House and the Brewster and other islands in view, as one advances toward Hull, are picturesque objects; and then the pleasant and sunny situation of the little village of Hull, furnishes a convenient resting place for the traveler.

In proceeding from this beach to Cape Cod, the observer should not fail to pass along the north shore of Cohasset—the most rocky place perhaps in the Commonwealth.

Cape Cod.

But after passing Duxbury, the region of sand and gravel commences; and to Provincetown, the extremity of Cape Cod, no genuine ledge of rocks appears; although bowlders of every size, over the greater part of the distance, are common.

The dunes or sand hills, which are often nearly or quite barren of vegetation, and of snowy whiteness, forcibly attract the attention on account of their peculiarity: while the numerous windmills and vats along the shore, for the manufacture of salt, are scarcely less interesting to one not familiar with such processes. As we approach the extremity of the Cape, the sand and the barrenness increase; and in not a few places, it would need only a party of Bedouins to cross the traveler's path to make him feel that he was in the depths of an Arabian or Lybian desert. Very different from Bedouins, however, will he find the inhabitants of Cape Cod. In the midst of the sands he will meet many an oasis, where comfortable and not unfrequently pleasant villages have sprung up, inhabited by a people of mild and obliging disposition, and not deficient in intelligence. A large proportion of the houses on the Cape are, indeed, but one story high. Yet they are for the most part convenient and comfortable; exhibiting the marks of a thrift and independence which one would not expect, when he considers the gen-

eral barrenness of the landscape. I could name several parts of Massachusetts, where the marks of poverty are far more striking than on Cape Cod.

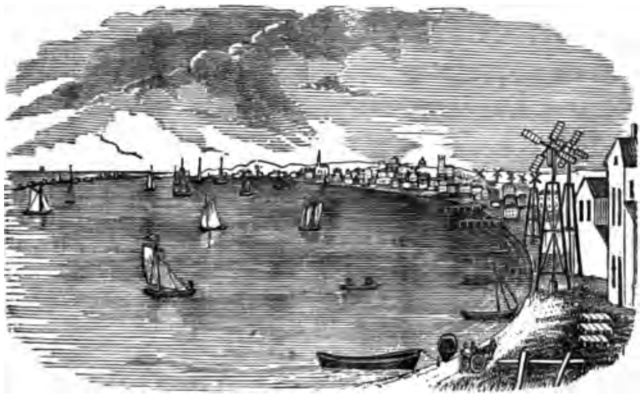
The sand is so yielding that the traveler will find it more convenient to leave his carriage 20 or 30 miles short of the extremity of the Cape, and proceed on horseback: though it is practicable to proceed with wheels. But for seven or eight miles before reaching Provincetown, he must find his way along the margin of a salt marsh during ebb tide. During flood tide, he will be forced to wade through the loose and deep sand higher up the beach. The view of Provincetown along this course, is so peculiar, that the traveler feels himself amply repaid for his labor. A semicircular bay is enclosed on the north and east by a sandy beach and low sand hills almost destitute of vegetation, which seem to threaten, and do in fact threaten, to bury the village, and to fill the harbor. The houses, for a population not much short of 2000, are erected on the margin of this bay, just above the reach of the tide, and at the foot of the sand hills. These dwellings are almost as destitute of order in their position, as it is possible they should be: only one regular street, wide enough for carriages to pass, being found here.* But the most singular object in this place, is the numerous windmills erected between the dwellings and the harbor, for pumping up the water into reservoirs for evaporation. When set in brisk motion by the wind, standing as they do between the traveler and the dwellings, as he comes from the south, they give to the village a most singular aspect.

The view of this town, which is given in Fig. 29, was taken from a point a few rods beyond the southeastern extremity of the village, and will give some idea, though an imperfect one, of those peculiar features of this landscape that have just been described. They are so unique and different from anything in the interior of New England, that a visit to this place by land in the summer would probably in many cases prove as effectual a remedy for ennui and other fashionable complaints, as a resort to Ballston or Saratoga. A daily stage goes down the Cape as far as Orleans: and from thence every other day a waggon proceeds to Provincetown; which might convey two or three passengers. From that place, packets run at irregular but not long intervals to Boston in a few hours. I do not doubt but this excursion, when the route becomes better known, will become quite

* A few years since even this did not exist here, and the whole place could scarcely have been more irregular, had the buildings all been constructed in the air and committed to a whirlwind to locate. That portion of the surplus revenue of the United States which fell to this town was very wisely expended in constructing a decent, though very crooked street through the whole town, and in forming a side-walk of plank. Scarcely anything could have contributed more to the comfort and appearance of the place. In the town meeting in which it was decided to make this application of the surplus revenue, one of the speakers remarked, that this money had proved a bone of contention in most places, and for his part he thought the best place for a bone was under foot, and therefore should vote for constructing a side walk with these funds.

common: and as the travel is increased, the means of transportation will be improved. Should it become sufficient to require a steam boat from Provincetown to Boston, I can hardly think of a route that would be more likely to interest and profit a large part of the community.

Fig. 29.



View of Provincetown.—Mrs. Hitchcock, del.

In crossing the sands of the Cape, I noticed a singular mirage or deception, which was also observed by my traveling companions. In Orleans, for instance, where the ocean is within a short distance on either hand, we seemed to be ascending at an angle of three or four degrees; nor was I convinced that such was not the case, until turning about I perceived that a similar ascent appeared in the road just passed over. I shall not attempt to explain this optical deception: but merely remark, that it is probably of the same kind, as that observed by Humboldt, on the Pampas of Venezuela; "all around us," says he, "the plains seemed to ascend towards the sky."

In crossing the island of Nantucket, in company with Dr. Swift of that place, I noticed the same phenomenon, though there less striking. After wards, I saw it for miles on the plain in the southeastern part of Martha's Vineyard. In the latter case, the plain was covered with low shrub oaks.

Nantucket and Martha's Vineyard.

If the traveler wishes to enjoy more of the peculiar scenery of Cape Cod, with some interesting variations, let him pass over to Nantucket and Martha's Vineyard. The former island he will find to be an extended plain, 15 miles in its longest direction, and but slightly elevated above the ocean; containing scarcely a tree, or a shrub of much size, except in the immediate

vicinity of the village. Scarcely a dwelling will meet his eye, out of the town, except a few uninhabited huts, scattered along the desolate shore, as a refuge to the shipwrecked sailor. Yet from 12000 to 14000 sheep, and 500 cows find nourishment on this island; and in not a few places, especially in the immediate vicinity of the town, may be seen tracts of land of superior fertility. It will strike the traveler at once, as an interesting monument of industry, that nearly every part of the dwellings, stores, &c., for the accommodation of more than 7000 inhabitants, must have been transported from the Continent. And on acquaintance, he will find that they still retain the characteristics of industry and hospitality, for which they have long been known; and that the usual concomitants of these virtues, general intelligence and strong local attachments, are not wanting.

Gay Head.

The most interesting spot on Martha's Vineyard is Gay Head; which constitutes the western extremity of this island, and consists of clays and sands of various colors. Its height cannot be more than 150 feet; yet its variegated aspect, and the richness of its colors, render it a striking and even splendid object, when seen from the ocean. The clays are red, blue and white; the sands, white and yellow; and the lignite, black; and each of these substances is abundant enough to be seen several miles distant, arranged in general in inclined strata; though from being unequally worn away, apparently mixed without much order. The top of the cliff is crowned by a light house, which commands an extensive prospect. Scarcely a tree is to be seen on this part of the island. It is owned and inhabited by the descendants of the Indian tribes, that once possessed the whole island. It will be seen in the subsequent part of my Report, that this spot possesses peculiar attractions for the geologist and mineralogist.

I have felt quite desirous of obtaining a good drawing of Gay Head, as seen from the ocean: but have never been accompanied thither by an artist except once; and then the wind was too powerful to allow putting off in an open boat. All, therefore, that could be done, was to take an oblique view of the cliff, as seen from a high bluff near its southern part, which advances several rods beyond the general surface. Fig. 30, exhibits the northern and greater part of the Head, with the Light House, and beyond this on the right, an Indian school house; and still more distant, cliffs in Chilmark: while on the left, beyond the water, are seen some of the Elizabeth Islands and a part of Falmouth. Every lover of natural scenery would be delighted to visit this spot. There is nothing to compare with it in New England;

and probably not in this country. It corresponds well with the cliffs of the Isle of Wight on the English coast.*

Fig. 30.

Gay Head. Mrs. Hitchcock, del.

WATER FALLS.

We have a few water falls in Massachusetts of sufficient magnitude to be denominated cataracts. And as we might expect in a mountainous region, cascades are numerous.

Turner's Falls.

These exist in Connecticut river, near the point where the towns of Montague, Gill, and Greenfield meet. They are by far the most interesting water fall in the State; and I think I may safely say in New England. At least, to my taste, the much broader sheet of water, the higher perpendicular descent, and the equally romantic scenery of the surrounding country, give to this cataract a much higher interest, than is excited by a view of the more celebrated Bellow's Falls on the same river, in Walpole, New Hampshire: and probably the latter are generally regarded as the most striking object of this kind in New England.

Above Turner's Falls, the Connecticut for about three miles, pursues a course nearly northwest, through a region scarcely yet disturbed by cultivation; and all this distance it is as placid as a mountain lake, even to the

* As it is extremely difficult to land with a good sized boat within several miles of Gay Head, the best way, though the most expensive, of going thither upon the whole, is, to take passage at New Bedford in the steam boat, which touches at the other extremity of the Island, where a carriage can be procured to go to the Head. It is to be regretted, however, that the road for the last five or six miles is so rough and crooked, that a guide and considerable courage are indispensable. Not less than 17 pairs of bars must be gone through. At the Head, the traveler can be very comfortably lodged with an Indian by the name of Thomas Cooper. So far as I have had intercourse with the aborigines residing here, I have been very favorably impressed with their shrewdness, industry, temperance, and general moral and religious character as a community.

verge of the cataract. Here an artificial dam has been erected, more than a thousand feet long, resting near the center upon two small islands. Over this dam the water leaps more than 30 feet perpendicularly; and for half a mile continues descending rapidly and foaming along its course. One hundred rods below the falls, the stream strikes directly against a lofty greenstone ridge, by which it is compelled to change its course towards the south at least a quarter of a circle.

The proper point for viewing Turner's Falls, is from the road leading to Greenfield, on the north shore, perhaps 50 rods below the cataract. Here from elevated ground, you have directly before you, the principal fall, intersected near the center by two small rocky islands, which are crowned by trees and brushwood. The observer perceives at once that Niagara is before him in miniature. These islands may be reached by a canoe from above the falls in perfect safety. Fifty rods below the cataract, a third most romantic little island lifts its evergreen head, an image of peace and security, in the midst of the agitated and foaming waters, swiftly gliding by. The placid aspect of the waters above the fall, calmly emerging from the moderately elevated and wooded hills at a distance, is finely contrasted with its foam and tumult below the cataract.

The country around these falls is but little cultivated. On the opposite side of the river the observer will, indeed, perceive a few dwellings and the head of a canal: But a little beyond, wooded elevations, chiefly covered with evergreens, terminate the landscape; while in every other direction, the scenery is still more wild and unreclaimed from a state of nature.

A sailing excursion from the falls, three miles up the stream, has all the attractions of a passage over a mountain lake, and probably the coves along the shore furnish as good spots for fishing as now exist in the river. The geologist too, will find the vicinity of these falls full of interest—but of this more hereafter.

Three miles above Turner's Falls, Miller's river empties into the Connecticut, over a dam about ten feet high. I apprehend these falls have been confounded with Turner's; and hence the latter are sometimes called Miller's Falls. They cannot, however, be said to have as yet any well established name. For a reason which will be mentioned below, I ventured some eighteen years since, in a geological account which I published of the Connecticut valley, to denominate these falls, *Turner's Falls;* and Gen. Hoyt, in his History of the Indian Wars, has given them the same designation. I am aware, however, how very difficult it is to make popular and prevalent, a new name for any natural object; although in the present case, I doubt not, that every man acquainted with the history of this spot, would say that to prefix the name of Capt. Turner to this cataract, is appropriate and just.

About 170 years ago, a party of Philip's Indians, having joined those living in the vicinity, resorted to these falls to take fish. On the 17th of May, Capt. Turner, from Boston, marched from Hatfield, with 150 men, and came by surprise upon the Indian camp the next morning at day light. The Indians being totally unprepared for an attack, fled in every direction; some springing into their canoes without paddles, were precipitated over the falls and dashed in pieces. Three hundred Indians, and but one white man were killed. Yet the Indians who escaped, being joined by others, fell upon Turner's party as they were returning, and made a dreadful slaughter among them; killing thirty seven, among whom was Capt. Turner. Will not the public do the justice to this brave but unfortunate officer, to send down his name to posterity, associated with that of the spot where he conquered and fell!

During high water, the roar of Turner's Falls may be heard from six to ten miles. The magnificence of the cataract is greatly heightened at such a season.

In order to visit Turner's Falls, one must turn aside from every great public road; and although but four miles from the village of Greenfield, this circumstance shows why they are so seldom resorted to by travelers. They are exhibited on Plate 10, as seen from the north shore below the cataract. Since the sketch was taken, I believe some few alterations have been made in the buildings upon the opposite shore.

Holyoke's Falls.

For two miles below Turner's Falls, the river presses hard upon a trap ridge, whose base is thus almost entirely denuded of soil, and the bed of the stream is too rocky and to rapid too admit of navigation; so that scarcely a spot in the state can be found so unfrequented as this. It was not till since the publication of my former reports, that I discovered the existence of another cataract about a mile below Turner's Falls, which, although less interesting than Turner's, is yet worthy of notice. The river is there divided by an island, as at Turner's Falls: but it is only the fall on the eastern branch that can be seen to advantage.

Plate 11, shows these falls as they appear upon the shore of the river a few rods south. Although the descent of the water is small, yet the projecting rocks from the bottom and the banks, the undisturbed forest trees upon the shores, and the distant blue hills, render the view highly romantic and deserving the attention of the man of taste. The road from Greenfield to Boston passess within half a mile of the spot, and the traveler can leave his carriage at the public house near the bridge over Connecticut river.

Associated with Capt. Turner in the expedition against the Indians at the upper falls already described, was Capt. Holyoke of Springfield. During the engagement at the falls, he was particularly forward and courageous; having it is said, killed five of the enemy with his own hand. And after Turner's reverse, Holyoke covered the rear; and after Turner's death, he assumed the command and brought off the party successfully. If, therefore, Turner deserves to have his name associated with the upper falls, certainly none will refuse the honor to Holyoke, which I now propose, by connecting his name with the lower falls.

Mitineaque Falls.

About a mile west of the village of West Springfield, Agawam river falls a few feet, and recently a dam has been erected of considerable height, so as to make a cataract of no small interest. The Spot is also attractive to the geologist, as the subsequent parts of my Report will show. Fig. 31, will convey a good idea of the general features of this spot.

Fig. 31.

Mitineaque Falls: W. Springfield.—H. J. Van Lennep, del.

Salmon Falls.

Following up Agawam river beyond Westfield, (where it takes the name of Westfield river,) until we come to the place where it issues from the mountains in Russell, and we shall there find Salmon Falls. It is a romantic spot; although the fall itself is not very imposing. But the rugged rocky island at the precipice, the Feeder to the Farmington and Northampton Canal, which is here commenced, and the grandeur of the surrounding mountains, powerfully awaken and keep alive the attention. Fig. 32, conveys but a poor idea of these falls, because it was taken at a point from which only a part of the objects above alluded to could be seen, and also because it is not very accurate.

Fig. 32.

Salmon Falls, on Westfield River.

Great Falls.

A few miles beyond Salmon Falls, but still within the bounds of Russell, another cataract of still greater interest exists on Westfield River. This is called Great Falls; and is at Gould's Mills, near the northwest corner of Russell. The bed and banks of the river here, as well as at Salmon Falls, are composed mostly of white coarse grained granite. This, as well as the slate rocks connected with it, is swept of soil, and deeply worn down in such a manner as to leave masses projecting from the sides and bottom of the river. At high water the falls are very imposing, and at low water the rocks just described, which show the powerful effects of water upon the solid frame work of the globe, are scarcely less interesting. The mountains around and ahead, as we look up the stream, are of the usual magnificent character exhibited in this ravine. Plate 12 exhibits Great Falls, as seen from a projecting point several rods below, on the eastern bank. The rail road cars are placed where the road is located; and where they will doubtless be seen in the autumn of 1840.

Pawtucket Falls on Merrimac River.

Pawtucket Falls, though of no great elevation, have given rise to the city of Lowell: for without them no water privilege would exist there. A little below the falls, a bridge is built across the river; and a little above them, is the head of Middlesex Canal. The bottom of the stream is composed of rocks, whose ragged aspect is finely contrasted with the smooth water and beautiful banks extending several miles above the city. Fig. 33, was sketched considerably below the bridge on the north bank.

Fig. 33.

Pawtucket Falls: Lowell.—H. J. Van Lennep, del.

Near the mouth of Concord river, which empties into the Merrimac, a little to the east of Lowell, is some scenery and one or two cascades well worthy of a visit. The deep cut for the rail road through the mica slate, a little south of the city, may be also mentioned as a place of interest, especially to the geologist.

Spicket Falls.

Spicket river is a tributary of the Merrimac on the north side; and a few miles above its mouth, near the center of Methuen, it falls 30 feet; partly however over an artificial dam. A flourishing manufacturing village has grown up around these falls: and although somewhat modified in appearance by the hand of man, they form an object of no little interest. Fig. 34, will give an idea of their prominent features.

Fig. 34.

Spicket Falls: Methuen.—H. J. Van Lennep, del.

Falls in Fall River.

Fall River is a small stream on the borders of Rhode Island, in the county of Bristol, emptying into Taunton River at the village of the same name. It takes its rise in a pond only a mile or two back of the town : but being precipitated down the bank at least a hundred feet, in the distance of as many rods, it forms a water privilege of great power, which has been most thoroughly improved. The extensive factories built of the excellent granite which is here so abundant, are usually placed directly across the stream ; so that when the whole of the water has been made to turn the machinery of one establishment, it passes into another immediately below it, to perform the same office ; and so on, till it reaches Taunton river. The fall, therefore, which must originally have formed a beautiful cascade, is almost entirely lost. But when we see how beautiful and extensive a village has been the consequence, we submit without murmuring to the loss. And besides, the fine view of Mount Hope Bay, with numerous other objects bordering the river, make the prospect from this village a delightful one.

Indian Orchard and Falls on Chicopee River.

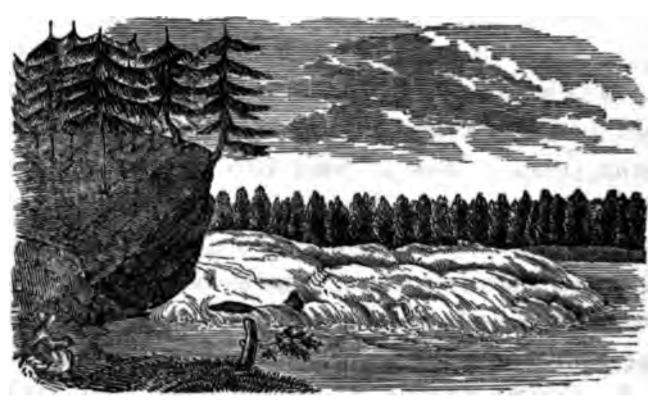
In the vicinity of Putt's Bridge, which crosses the Chicopee river from the northeast part of Springfield into the southwest part of Ludlow, is a manufacturing village ; and at least two interesting falls of water. The principal one lies half a mile down the stream from the village, and the spot goes by the name of Indian Orchard. Fig. 35, is a view of this spot from the high bank on the north shore, a little below the falls.—Standing there you see the water pouring down a steep though not perpendicular declivity of sandstone, and issuing from a deep gorge which its waters have worn in the rock. Just below the falls, the waters form a beautiful basin, with a lovely island near its center, and surrounded on the south and west by an unbroken forest ; so that at this place you scarcely see the marks of human agency at all. The contrast between the waters as they they issue foaming and dashing from the gorge and down the steep, and those same waters as they lie almost without a ruffle in the basin below, beautifully reflecting the surrounding hills and trees, is extremely pleasing.

Fig. 35.

Indian Orchard: Springfield.—H. J. Van Lennep, del.

If we quit the spot whence the above was taken, and approach the place where the waters issue from the gulf which they have cut in the rocks, we shall find on the north side, an overhanging precipice of some 50 or 60 feet, whose edge it needs some nerve to approach, and steadily to look over. Fig. 36, is intended to show the manner in which this sandstone cliff hangs over the water.

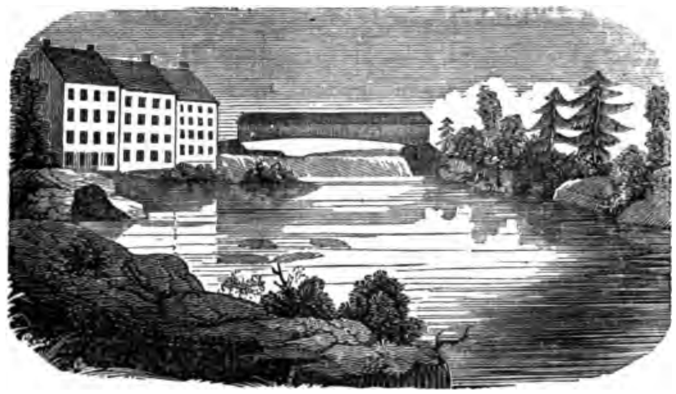
Fig. 36.



Falls at Indian Orchard.—H. J. Van Lennep, del.

It is interesting to follow the deep windings of the river from these falls to Putt's Bridge, overshadowed as it is by thick forests most of the distance, and often presenting romantic views. When we reach the first factory upon its bank, from a point of land projecting into the river, a little below the buildings, we get a pleasing view of another fall with Putt's Bridge passing over the river in the vicinity. And though to the lover of nature in her wildness, the buildings upon the banks detract from the beauty of this spot, yet the landscape is by no means to be despised. Fig. 37, is a representation of it as seen from the point above named.

Fig. 37.



View at Putt's Bridge: Ludlow.—H. J. Van Lennep, del.

Upon the whole, Indian Orchard and its vicinity are well worth the attention of the man of taste. A half day may be spent here in a most agreeable manner, and I am surprised that it is not more known and visited.

Gorges and Falls in Royalston.

There are at least three water falls connected with deep gorges in Royalston, that are well worthy the attention of those who are fond of wild natural scenery. About a mile west of the meeting house and center of the town, is a deep valley running north and south, nearly across the town. Near the meeting house is a pond which empties itself into this valley by plunging rapidly down a steep declivity, which must be 800 or 1000 feet high. It there empties into another large pond, or rather a remarkable expansion of a small tributary of Millers' river. At one part of the descent of the brook above named, it falls at least 200 feet by several leaps, within a distance of a few rods, forming several very beautiful cascades. Here the original forests have not been disturbed. The trees overhang the murmuring waters, half concealing the stream, while broken trunks are plunged across it in all positions.

In the extreme northwest part of the town, on the farm of Calvin Forbes, a gorge and cascade exist of still greater interest: one of the finest indeed in the state. The stream is not more than 10 feet wide at the spot, but it descends 45 feet at a single leap, into a large basin, which from its top has been excavated by the erosion of the waters. The sides, to the height of 50 or 60 feet, are formed of solid rocks; now retreating and now projecting: crowned at their summit by trees. Many of these lean over the gulf, or have fallen across it; so that upon the whole, the scene is one of great wildness and interest,

Plate 13, exhibits this spot as seen from below the falls. It certainly deserves a name; and until a better one shall be proposed, I would suggest that of *The Royal Cascade;* partly in reference to the name of the town in which it is situated, and partly in reference to its *royal* character.

Two miles south of Royalston center, on the road leading to Athol, is another cascade on a larger stream. Its width indeed, must be as much as 25 feet, and the depth considerable. In a short distance the water here descends, at several successive leaps, as much as 200 feet, between high walls of gneiss and granite. Towards the upper part of the descent, several mills are erected: but a small part only of the water power is employed. Below the mills, the stream passes into the woods: and towards the lowest part of the descent, we get a single view of two falls of about 25 feet each. This is sketched on Fig. 38, from which it appears that there is more of beauty and less of wildness at this spot than at the Royal Cascade. This stream also has been, and still more extensively can be, applied to useful purposes. Perhaps tnerefore, considering the character of our political institutions, and our well known reputatiou for *utilitarian* tendencies, this, rather in contrast to the Royal Cascade, may be denominated the *Rcpublican Cascade.* But if I can induce persons of taste and leisure to visit it, I care but little for the name.

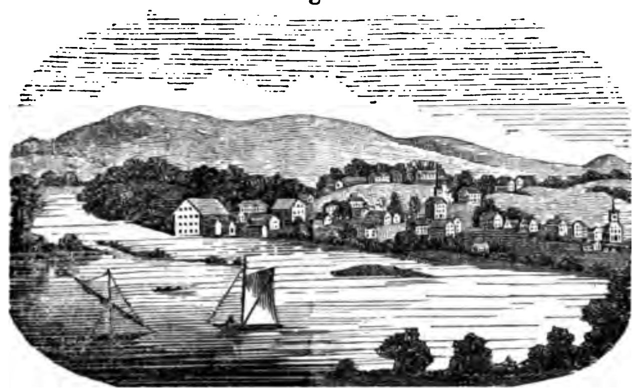
Fig 38.

Cascade: Royalston.—H. J. Van Lennep, del.

Falls at South Hadley in Connecticut River.

The descent of the water here being but a few feet, these falls do not in themselves possess any great interest; and yet, as one of the objects in the beautiful landscape which has already been described as existing at this place, their absence would be sensibly felt by the man of taste. Fig. 39, will convey some idea of this spot.

Fig. 39.



South Hadley Canal.—Mrs. Hitchcock, del.

Shelburne Falls.

These occur in Deerfield river where it enters the narrowest part of that deep ravine in the primary strata, between Shelburne and Conway, which has been already described. As a mere object of scenery they are not so striking as Turner's Falls; though they exhibit not a little of wildness and sublimity; and they are especially worth a visit from the geologist, as affording a good exhibition of the effects of a mountain torrent upon the hardest of rocks.

The Gorge, or Glen in Leyden.

In the south part of Leyden, a large brook has worn a passage from 10 to 20 feet wide, and from 30 to 50 feet deep, in the strata of argillo-micaceous slate. The layers of the slate are nearly perpendicular, and it is traversed by numerous cross seams, into which the water penetrates, and in winter freezes, expands, and thus assists in removing mass after mass of the rock from its place. A slight inspection of the place will show that such was the mode of its formation; although one cannot but perceive that a great length of time was requisite for the whole process. There is not the slightest appearance of any convulsion at this place, since the original elevation of the strata. The correspondence between the salient and reentering angles on opposite sides of this stream, is no greater than exists in every stream; and all the appearances at the place forbid the supposition often made that these sides have been separated from each other. The length of this gorge is from 30 to 40 rods. Above is a deep glen; and below, the stream passes through a deep ravine. Two water falls near the lower part of the gorge add much to the interest of this spot. And although the geological chronometer here exhibited, is to the reflecting mind, its greatest attraction: yet the

wildness and ruggedness of the scenery draw not a few visitors. The term "glen," usually applied to this spot, is certainly a misnomer. For it is a gorge connecting a glen with a ravine, Fig. 40, was sketched below the principal cascade.

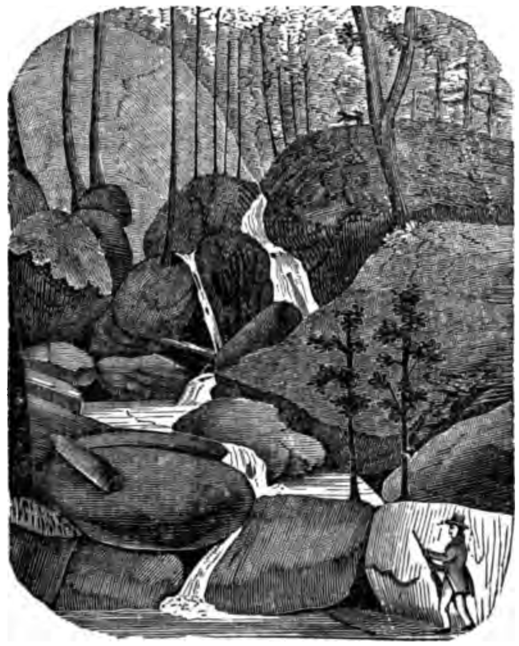
Fig. 40.

Gorge or Glen: Leyden.—Mrs. Hitchcock, del.

Cascade in Leverett.

I have recently ascertained the existence of an interesting water fall on northeast side of Mount Toby, in Leverett. The conglomerate rock of that mountain has been subject to powerful abrasion in early times; and being divisible into masses of great thickness, by fissures nearly perpendicular to the horizon, the sides of the mountain frequently present perpendicular walls of solid rock, and sometimes a succession of precipices in the form of vast steps; while the huge fragments that have fallen down, lie scattered along the base. Such is the case at the spot above referred to: where a large brook, called "roaring brook," comes tumbling down by a few successive leaps from the height of 200 or 300 feet. The waters have worn deep chasms in the rocks, and the scenery around is of the wildest and most romantic character. Every thing there—the lofty forests—the overhanging precipices—and the accumulated rocky masses below—remain unmodified by the hand of man, just as the mighty agencies of nature have left them. This will be obvious from Fig. 41.

Fig. 41.



Cascade in Leverett.—H. J. Van Lennep, del.

Cascade, Natural Bridge, and Fissure, on Hudson's Brook.

The present falls on this rivulet, which runs through the north part of Adams, are of far less interest than the deep chasm which its waters have excavated in the white limestone. This limestone terminates on the south in a high precipice, over which the stream once fell. But it has worn a fissure from 30 to 60 feet deep, and 30 rods long, in this limestone, and left two masses of rock connecting the sides and forming natural bridges: though the upper one is much broken. The lower one is arched, and the stream at present runs 50 feet below it. The medium width of the stream is 15 feet.

Within a few years past, the drill of the quarryman has begun its assaults upon the beautiful white limestone that forms this natural bridge, and the walls of the gorge: and although the intelligent proprietor, whom I met there, partially promised me that he would not mar the beauty of this spot, yet the deep inroads already made upon the upper part of the cliff, are fearfully ominous of the fate of the whole. As I saw it last, the clearing away of some of the rock had brought the natural bridge more distinctly into view. Yet the next advance would take it entirely away. And lest this should be accomplished before a skillful artist shall visit this spot, I thought it better that a sketch should be taken by one not at all accustomed to drawing; than that no memento should be left of this interesting place. Such a sketch is shown in Fig. 42.

Fig. 42.

Natural Bridge: Adams.

Umpachena Falls.

The Umpachena is a small stream, rising in the east part of New Marlborough, and passing westerly, unites with the Konkapot; which is a tributary of the Housatonic. Both these streams take their names from those of Indian chiefs, who formerly had possession of that region. Towads the west part of New Marlborough, the Umpachena falls over horizontal strata of quartz rock, by two leaps, to the depth of about 30 feet, the upper cataract being 10 feet. Although there is nothing very striking about these falls, yet there is enough that is peculiar to make them worthy the attention of one who would not pass by any of the interesting natural objects of Berkshire County.

Bashapish, or Bash-Pish Falls and Gorge.

Bashapish or Bash-Pish Falls and Gorge, are upon a small, and so far as I could learn, a nameless stream, passing westward from the center of Mount Washington, through the Taconic range, into New York: near the line of which, they occur. Although the most remarkable and interesting gorge and cascade in Massachusetts, it was only by accident that I learnt their existence, after having been in Mount Washington for sometime. And at that time, I could scarcely find any one in the neighboring towns who had heard of the

spot. I give the name as I heard it pronounced. I shall not undertake to decide upon its etymology: though I perceive that some would derive it from the German, and others from the Indian. I wish the name were better: but it is not so bad as it might be; and it will probably be no easy matter to alter it. Whatever may be thought of the name, however, all I think who visit it, will consider the place itself as highly interesting. But it is quite difficult to convey an adequate idea of it by simple description.

In the first place, it is an enterprise of no small magnitude to get to the spot; especially for ladies: none of whom but the most resolute and vigorous should attempt it, until the roads are improved, or rather *made:* for the main difficulty is, there are no roads that are tolerable for carriages within two miles of the place. A few years since there was a very decent road from Copake in N. York, it being only four miles east of Miller's tavern. But the powerful rains of the summer of 18:8, completely ruined it, so that it will be quite as easy to make a new one as to repair the old one. The best course to reach this spot, is to go into Mount Washington from Egremont, as already described in another place, and when you have proceeded as far as the first school house, you will find yourself in the vicinity of a Mr. Schott; at whose house it is better to leave your carriage, and go on foot the remaining two miles. The course lies mostly through the woods, and passes near the thermal spring that has been described in the first part of my report. A little beyond this, and just west of the highest ridge of the mountain, where is some cleared land, a very commanding prospect opens into New York, through the deep valley which is formed by a small stream, bounded on the right and left by the steep slopes of the mountain thus dissevered, and showing ridge beyond ridge, and checkered with woods and cultivated fields, and now and then a sheet of water, until at length the noble Catskill looms up above everything else in the far distant horizon. Fig. 43, will give some idea of this exhilarating prospect. It deserves to be sketched and engraved in a better style.

Fig. 43.

Distant View of the Catskills from Mt. Washington.—H. J. Van Lennep, del.

After leaving this spot, you descend a steep hill, nearly 2000 feet, and find yourself on the margin of a small stream, not much more than a rod wide, a little above the point where it begins to plunge and roar down the deep and dark gulf. For a few rods it descends rapidly towards the west, between perpendicular walls of rock, nearly 100 feet high. This rock is talcose slate, whose layers here stand nearly perpendicular, and run north and south, that is, across the course of the current. But ere long the descending stream strikes against a perpendicular mass of rock, which it has not yet been able to force out of its place, and is thereby made to turn almost at right angles to the left, and then to rush down a declivity sloping at an angle of about 80°, in a trough between the strata. This fall cannot be less than 50 or 60 feet; and here the water has performed its greatest wonders. Having for centuries been dashing against the edges of the strata, while at the same time its bed has been sinking, it has worn out a dome shaped cavity to the depth of 194 feet; that is, measuring from the top of the overhanging cliff to the foot of the fall. By creeping along the south side of the stream, where the wall is nearly perpendicular, one can descend to the bottom of the fall; and there he finds himself at the foot of a vast wall of rock, which as he faces the northwest, whither the stream turns its course at the foot of the fall, encloses him on the east, south, and west; and as it rises, it curves outward, so that when he looks up, he sees it at the height of nearly 200 feet, projecting beyond the base as much as 25 feet. A man in such a spot cannot but feel in some measure his impotence: for should only one of these overhanging masses fall, he knows that it would grind him to powder. And when he sees numerous fissures running through the cliff, he cannot feel entirely safe: or rather, it requires several visits to the spot to get his nerves accustomed to the slight danger that exists. The spot where he stands the sun never visits, except by reflection: and he seems to stand at the further extremity of a vast oven, or rather a bathing house. The only opening is down the stream, which continues to descend by successive cascades, until soon it is hidden by the vast blocks of stone, which are there accumulated, and by the overhanging trees. The banks on either hand rise in a very precipitous manner: and through the opening between them, the eyes rests upon a lofty slope, almost naked of trees, at the distance of nearly a mile. I consider the view from this spot through this opening to be very grand and striking; and therefore Fig. 44, though sketched by an unskilful hand, is given. On the right is seen the cascade above described, with the steep hill down which it rushes. On the left hand, is seen the lofty and even overhanging rock that forms the other bank, while between them in the distance, rises the vast slope of a part of the Taconic range and intercepts the view.

Fig 44.

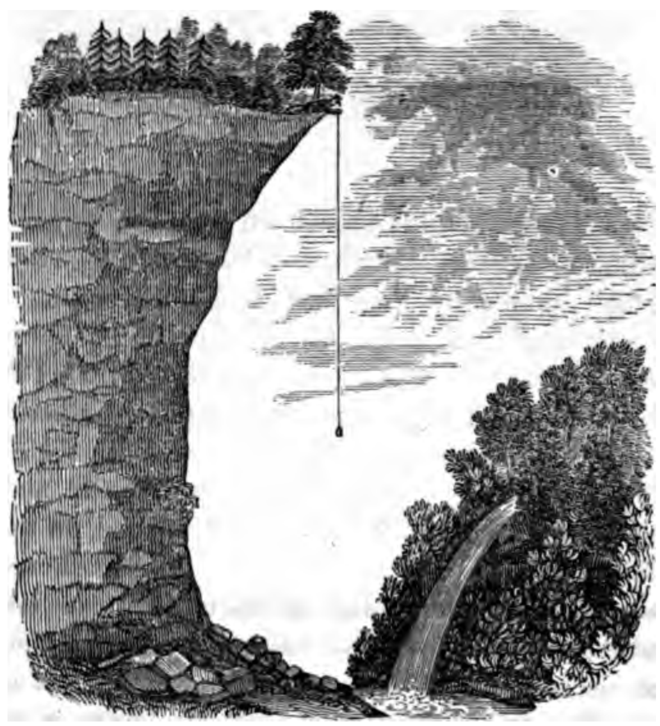
Bashapish Upper Falls.

Following the small stream still farther down from this upper fall, we find it rapidly descending by several smaller cascades, which together amount to at least 50 feet, half hidden by huge bowlders, and overhanging trees. At length we arrive at a larger and in fact the principal fall. The water which is divided into two parts by an enormous bowlder poised upon the brink, here falls over a nearly straight and perpendicular precipice of about 60 feet, into a deep basin, two or three rods across. Below these falls, and from the north bank, the view on Plate 14 was taken. This shows beyond and above the falls, the high and overhanging precipice above described, on the south side of the stream; and in fact, the best general view of the whole scenery of this spot may be obtained at this place. But no single view can take in only a small part of that scenery. Below these falls, the water continues to descend and forms several cascades, which in other places would be of interest: but here they are scarcely worth visiting after a person has seen those which I have described.

The object, which I think most persons would regard as the most striking, remains yet to be visited. Let the observer either follow back the rough path he has just trodden on the south side of the stream, or follow by a circuitous route the north bank, until he reaches the spot above the upper falls where he first entered the gorge, and there he will find a steep foot path that will conduct him to the top of the precipice that overhangs the upper falls sketched on Fig, 45. This is mostly covered by bushes: yet in one place he can advance to its very edge, and as the edge projects upwards a little, it

is well adapted to prevent one from falling over: as may be seen on Fig. 45, which will give an idea of the situation of the observer as he looks down into this gulf. On letting down a stone from this spot, with a string attached, I found that it required a length of 194 feet before the water was reached. I have scarcely ever felt such a creeping and shrinking of the nerves and such a disposition to draw back as here. Even though I took hold of bushes with both hands, I could not comfortably keep my eye turned long into the frightful and yawing gulf: for it seemed as if it needed only a stamp of the foot, or perchance only my weight, to cause the rock on which I stood to follow the example of multitudes of the same kind that were strewed at its base. Still I suppose the actual danger to be quite small.

Fig. 45.



Section at Bushapish Upper Falls.

Many persons, who visit these falls do not ascend this precipice. But they thus lose more than half the interest of the scene. Others examine the several objects in a reverse order from that which I have described: that is, they go first to the lower falls and follow the stream upwards. But I am inclined to beleive that the effect is most favorable to follow the route which I have described. I have now visited the spot three times, and with scarcely any diminution of interest. But I feel the poverty of description for delineating such scenery. From the top of the highest precipice to the foot of the lower falls, I estimate the perpendicular height to be about 320 feet.

From the account which I have given of Mount Washington, it appears that the town contains an unusual amount of objects of scenographical interest. To examine the most important, two days at least are indispensable: one to ascend Mount Everett, and the other to explore the scenery of Bashapish falls. To one who has a taste for the wild, the romantic, and the grand in nature, those two days will be a season of delightful emotions.

CAVERNS AND FISSURES.

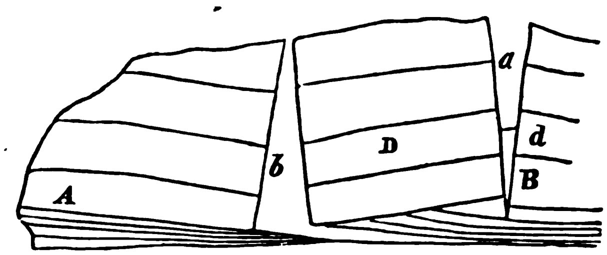
Southampton Adit.

I have alluded in the first part of my Report, to this artificial excavation, 900 feet in length, at the lead mine in Southampton. It is a perforation mostly in solid rock, large enough to admit a boat with several persons; and in this manner might be entered with perfect safety. Being unique in this part of the country, it had become a place of considerable resort by gentlemen and ladies during the summer months. At present the entrance is blocked up; but it is to be hoped that ere long the working of this adit will be resumed, and an opportunity again afforded for so fine a subterranean excursion.

Sunderland Cave and Fissure.

The following section will, I apprehend, render intelligible, not merely the form and situation of this cave and fissure, but also the mode of their production. They occur in a conglomerate rock of the new red sandstone, on the northwest side of Mount Toby, in the north part of Sunderland. The conglomerate strata are several feet thick: and immediately beneath this rock lies a slaty micaceous sandstone, which is very subject to disintegration; as may be seen a little north of the cave, where the conglomerate projects several feet beyond the slate, whose ruins are scattered around. The spot is perhaps 300 or 400 feet above Connecticut river: yet there is the most conclusive proof in all the region around, that water once acted powerfully, and probably for a long period, at various elevations on the sides of this mountain: and not improbably this aqueous agency assisted in undermining the conglomerate rock by wearing away the sandstone.

Fig. 46.



At *A*, and *B*, Fig. 46, the rock is but slightly removed from it original position; but in the space between these points, the slate appears to have been worn away so as to cause the whole conglomerate stratum, which is from 50 to 60 feet thick, and consequently of immense weight, to fall down, producing the fissure *a*, and the cavern *b*. The fissure is nine feet wide at the top, and open to *d*, 40 feet; below which it is filled with rubbish. The cavern is wider than this in some parts, though very irregular in this respect. Its bottom also is rendered quite uneven by the large masses of rock that have tumbled down. In the deepest spot, (56 feet) the rocks are separated to the surface, so as to let in the light from above. The whole length of the cavern is 148 feet. Its general direction is nearly east and west. But towards its eastern part it turns almost at right angles to the left, in consequence of the rock *a*, having been broken in a north and south direction from the mass of the mountain.

Some who visit this spot are disposed to call in the aid of a convulsion like an earthquake to explain the huge fractures there exhibited. But after seeing so many other marks of the powerful action of atmospheric and aqueous agents on this mountain, I cannot but believe the cause I have assigned to be sufficient. The place is well worth visiting by all who have not examined other caverns and fissures extensively.

On the opposite side of Mount Toby, a little south of the cascade that has been described, one or two other caves occur, more irregular but less extensive than this. They have been produced by the enormous masses of the mountain that have been here mixed *pell-mell* together.

Caverns in Berkshire.

These all occur in limestone: and are so similar, that it is hardly necessary to describe them separately. Two exist in the south part of New Marlborough, containing several apartments and some stalactites.

Small caverns exist in Egremont, Alford and West Stockbridge. In Lanesborough, at Baker's quarry, in the northwest part of the town, is a cavern of considerable extent, produced by the erosion of water. It descends northeasterly at an angle of 10° to 15°, and is generally not much larger than is necessary for a man to pass along. Indeed, I found it not easy to penetrate it more than 140 feet; though it is said to have been explored 300 feet. Stalactites occur there of some interest, but not abundant nor handsome. The singular calcareous deposit upon the floor of this cavern, I shall describe in another place. In Adams, a mile south of the north village, is a cavern in limestone of considerable extent. The largest apartment is 30 feet long, 20 feet wide, and 20 feet high. In Williamstown, at the foot of Saddle Mountain, I noticed one or two cases in which streams of some size disappear beneath the surface for several rods in the limestone rock: and here we probably see the manner in which most of the caverns that have been described above were produced.

Purgatories.

I know not what fancied resemblances have applied this whimsical name to several extensive fissures in the rocks of New England. The most remarkable case of this kind is in Sutton, three and a half miles southeast of the congregational meeting house. It is a fissure in gneiss, nearly half a mile long, in most parts partially filled by the masses of rock that have been detached from the walls. The sides are often perpendicular, and sometimes 70 feet high; being separated from each other about 50 feet.

This is an immense chasm: and I confess myself at a loss to explain its origin. It is natural to suppose that its sides have been in some manner separated from one another. But I can conceive of no mode in which this could have been accomplished, but by a force acting beneath: and this would so elevate the strata, that they would dip on both sides *from* the fissure. But I could discover no such dip. The inclination along the fissure corresponds with that which is common in the region around; viz. about 25° N. E. In the vicinity of the fissure, however, the rocks are often exceedingly broken into fragments:* and this circumstance indicates some early subterranean convulsion or the agency or troubled waters: And I am rather inclined to refer these fragments as well as the fissure, to the long continued action of the waves of the sea, when the spot was so situated as to form a shore of moderate

* Visitors of the Sutton Purgatory should recollect that such broken rocks furnish a fine retreat for the Rattlesnake. I met with one among the *debris* of that place. But as he kindly warned me that I was trespassing on his territory, I thought it ungenerous to attack him, and we parted on good terms, mutually willing to be rid of each other's company.

elevation. The case of a purgatory in Newport which I shall describe, will illustrate the mode in which the waves might have produced such effects.

In Great Barrington.

A fissure very similar to that in Sutton, exists in the mountain east of the village of Great Barrington. The best way to reach it, is to pass around the north end of the mountain, and then to go southerly a mile or two, as far as the house of Russell Kilbourn: from whence a walk of three quarters of a mile will lead to the spot. It is an open fissure, about 4 rods wide, with perpendicular walls, which in some places rise to the height of 80 feet. The bottom in most parts is strewed over with loose but not rounded blocks, which were obviously derived from the sides. This detritus frequently fills up the bottom several feet; so that probably the entire depth cannot be much less than 100 feet. Among the loose masses of rock, snow and ice frequently remain through the summer. I found them there in abundance on the 25th, of June in a very sultry day.*

This Purgatory is in gneiss, which a good deal resembles that in Sutton. The strata in Great Barrington are nearly horizontal: and the fissure is nearly straight; but at its western extremity, the sides rather diverge. It runs S. 25° W. and N. 25° E. and extends across the entire ridge of the mountain, at least 80 rods in length. Its bottom cannot be less I think than 800 feet above the bed of the Housatonic. I can mention no explanation of the manner in which it has been produced, except the one suggested in regard to the Sutton Purgatory; and which will I think receive some illustration from certain fissures on the coast of Rhode Island; which I therefore introduce in this place. To persons, however, who are but little familiar with geological changes, probably the explanation which I give of these so peculiar phenomena, will seem no better than wild hypothesis.

In Newport, Rhode Island.

In the southeast part of this town (perhaps it is within the limits of Middleton,) the coarse conglomerate rock contains numerous cross seams, which are parallel to one another, and nearly perpendicular to the horizon. In one spot, in a high rocky bluff, two of these fissures occur not more than six or eight feet asunder; and the waves have succeeded in the course of ages, in wearing away the intervening rock, so as to form a chasm about

* It was amusing to see the effect of the ice at the bottom upon the musquetos, which were very troublesome. But if one wished to escape them, he had only to step down a few feet towards the bottom, where the temperature was so much lower, that they would not follow.

seven rods in length, and 60 or 70 feet deep; the sides being almost exactly perpendicular. This chasm is called Purgatory; and the waves still continue their slow but certain work of destruction.

On the south shore of Newport, a similar fissure occurs in granite. It is, however, much less extensive, not more than twenty feet deep perhaps: and the waves sometimes rush into it with such violence that they are dashed not less than thirty feet into the air. Even granite yields under this everlasting concussion. This spot is called the Spouting Cave.

We have only to suppose the Sutton and Great Barrington Purgatory to have been once similarly situated in respect to the ocean, and we have a cause adequate to its production. And yet, what an immense period must the whole work have demanded!

Autumnal Scenery.

Perhaps no country in the world exhibits in its autumnal scenery, so rich a variety of colors in the foliage of trees, as our own. But it is particularly beautiful in the more mountainous parts of the land. The trees, whose leaves give the liveliest tints, are the maple, the oak, the walnut, and the sumach: while the pine and hemlock retain their deep green: and if these species be fantastically mixed on a mountain's side, they present a splendid drapery, which, though somewhat approaching to the gaudy, is yet extremely interesting. The change generally commences as early as the middle of September, and does not attain its full perfection till after several frosts of considerable severity. The change proceeds undoubtedly from an increased oxygenation of the coloring matter of the leaves; analogous changes being easily produced in the chemical laboratory by the addition of oxygen to certain compounds,* as for example, the *Chameleon Mineral.* This process in the eyes of a chemist does not seem, as I believe it does to most men, a condition of sickness connected with the decay and fall of the leaf. He views it rather as a beautiful illustration of the means which nature possesses to produce variety. True, it is one of the more advanced steps of vegetable life; but does not seem to be disease. Or if any are disposed to consider it such, it ought to be looked upon as nature descending joyfully in her richest dress into her wintery grave, in exulting anticipation of a speedy resurrection.

Although this phenomenon forms an attractive object to the geologist in his wildest excursions among the mountains, at the most delightful season in the whole year for geological research, yet it cannot be regarded as having any connection with geology.

*Annales de Chimie et de Physique, Vol. 38, p. 415.

In my former report, however, I ventured to give a sketch of this scenery which is in a good measure peculiar to this country* but I have not felt justified in repeating this step in the present report; chiefly because the other drawings have been so multiplied. There is less need of a drawing also, because the splendid original is before all our citizens nearly every autumn. The autumnal scenery of other lands may be dispiriting and dreary: not so in ours.

> "What is there saddening in the Autumn leaves?
> Have they that "green and yellow Melancholy,"
> That the sweet poet spake of?—Had he seen
> *Our* variegated woods, when first the frost
> Turns into beauty all October's charms—
> When the dread fever quits us—when the storms
> Of the wild Equinox, with all its wet,
> Has left the land, as the first deluge left it
> With a bright bow of many colors hung
> Upon the forest tops—he had not sighed."
>
> *Brainard.*

Concluding Remarks.

Such essentially is the scenery of Massachusetts. I do not flatter myself that I have described, or even found, all the spots interesting enough to deserve a notice in this place. For up to the present time almost, I have continued to discover new places of scenographical interest; and whoever will take the trouble to compare my present with my former reports, will see that such discoveries have been very numerous within a few years past.

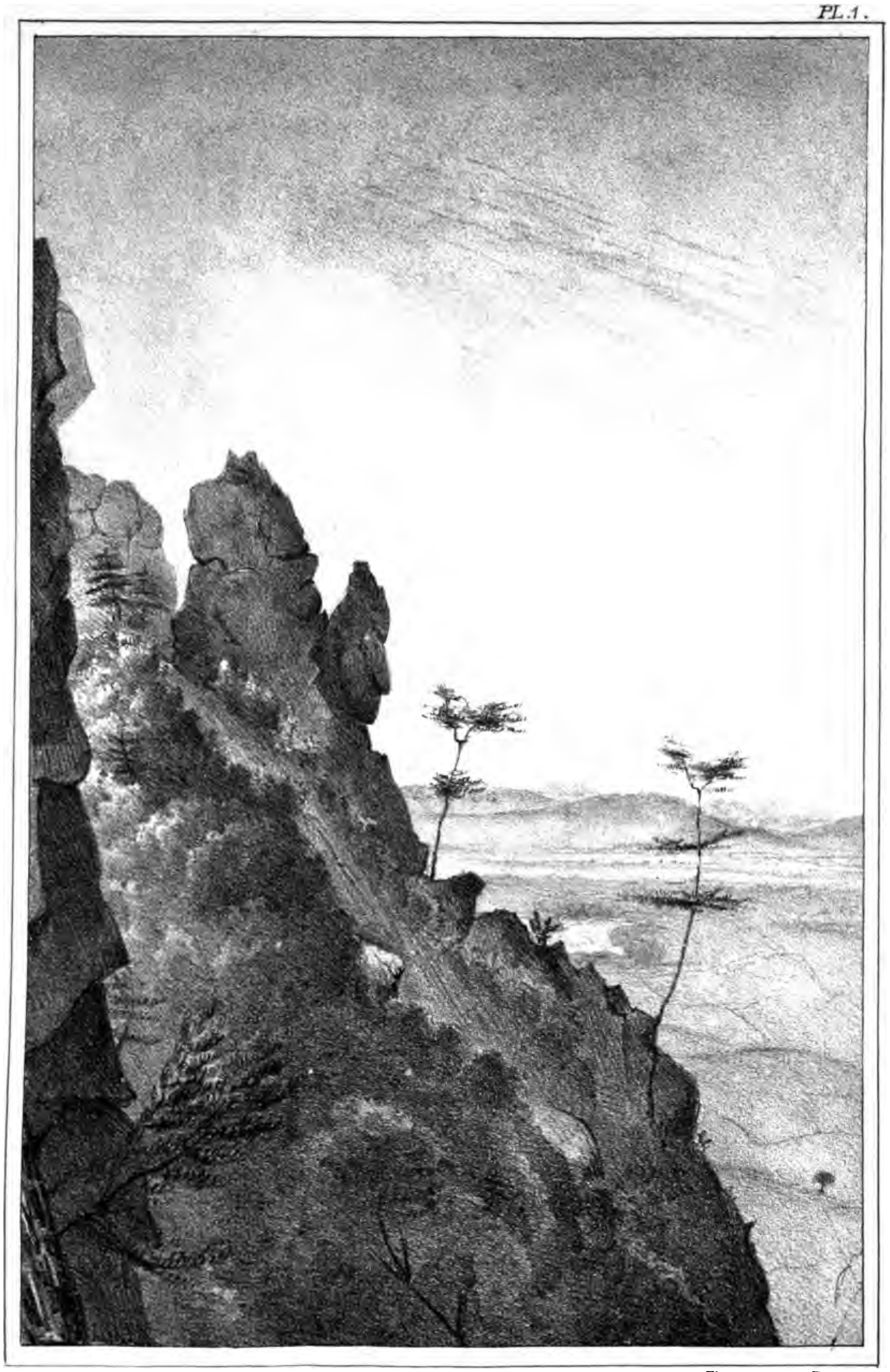
And now I earnestly wish that I could communicate to my readers were it but a moiety of the pleasure which I have experienced from an examination of the scenery of the state. But unless I can persuade them to follow my steps, my wish will be vain. But I will suppose that during the summer months, a few gentlemen of taste and intelligence—accompanied by ladies if they please—should wish to exchange the heat of the city, and routine of business for a few weeks of mountain air and alpine scenery. Let them go to Berkshire, and commencing at either extremity, pay a visit to the principal objects which I have described in the preceeding account of our scenery.

* It may not be improper, perhaps, to repeat the remarks made to me by the Baron Roenne, the present worthy Minister of Prussia to this country. Soon after he came here, he saw the drawing of autumnal scenery in my report, and at once pronounced it to be a caricature. But after residing in New England through one autumn, he declared that the drawing fell short of nature. But said he, "I shall be obliged to certify to my friends in Prussia that your drawing is correct, or they will not believe you."

Rev. Justin Perkins, American Missionary in Persia, showed one of these sketches to the Nestorians; who exclaimed; "what a strange country America must be! where they live in wooden houses and the trees are painted!"

In that county alone, they will find enough to occupy them for at least two or three weeks: And so great will they find the variety to be in the scenery of those mountains and vales, that the danger will be, not that they will be uninterested, but that the exhilaration will be too great: And yet this kind of excitement is usually very favorable to health: and I doubt not they would return invigorated for their ordinary pursuits. Or if they have still more leisure, let them wander through the beautiful valley of the Connecticut; and along its tributaries. Then let them visit the Wachusett, and other romantic spots of Worcester county, and pass down the Merrimac: the calm loveliness of whose scenery will most agreeably terminate the excursion. For the varied and unique scenery of our sea coast should be reserved for another excursion; and so contrasted is much of it with that in the interior, that it will not prove the less interesting, because the latter has been previously examined. In short, could our citizens but realize the riches of our scenery, I am sure so many of them would not resort so often to distant spots, beyond our limits, to experience often less gratification than they might find among our own mountains and vales.

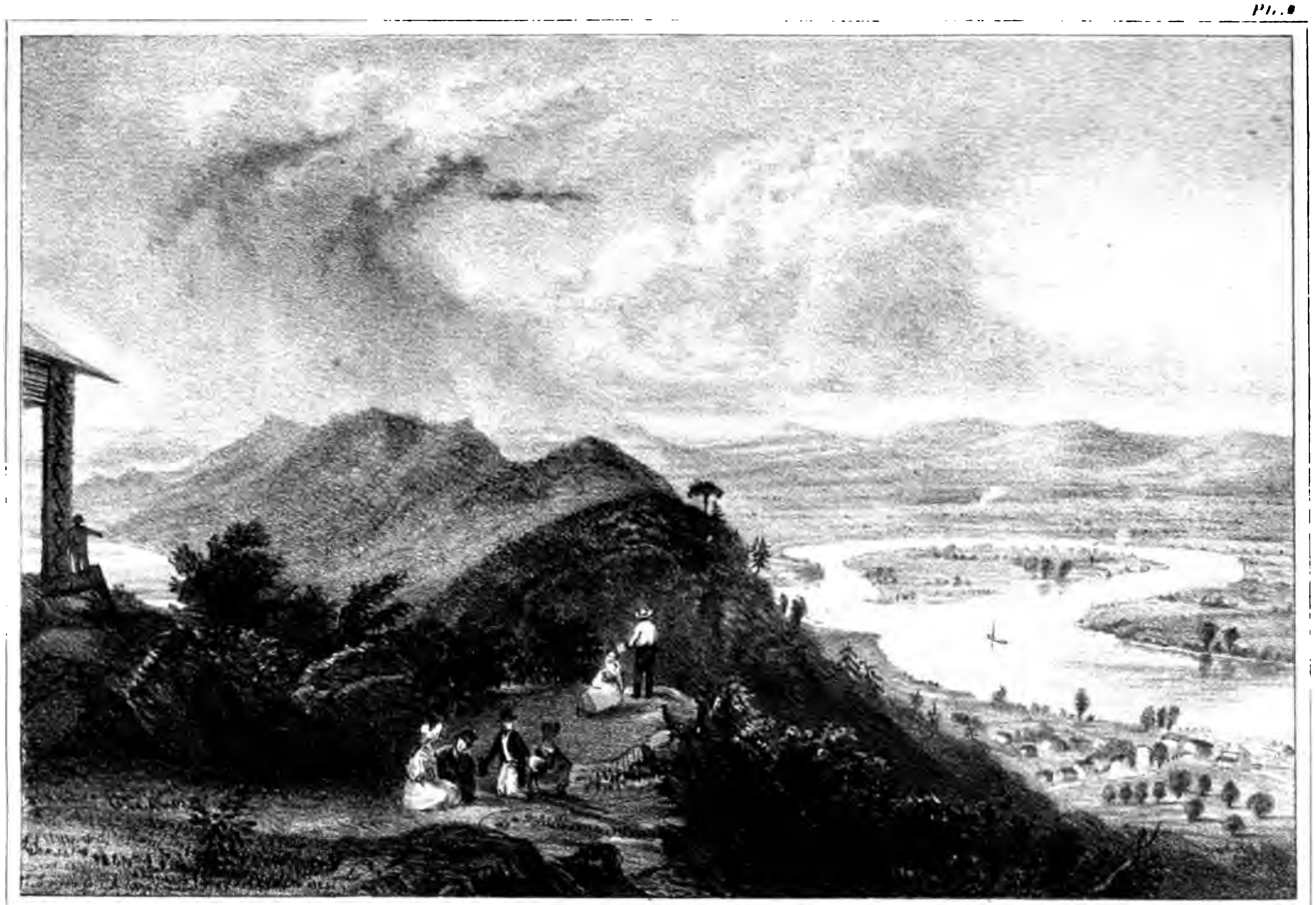
PL. 1.



Thayer's Lith. Boston.

PULPIT ROCK ON MONUMENT M^T

Pl. 8



Thayer's Lith. Boston

VIEW FROM MOUNT HOLYOKE.

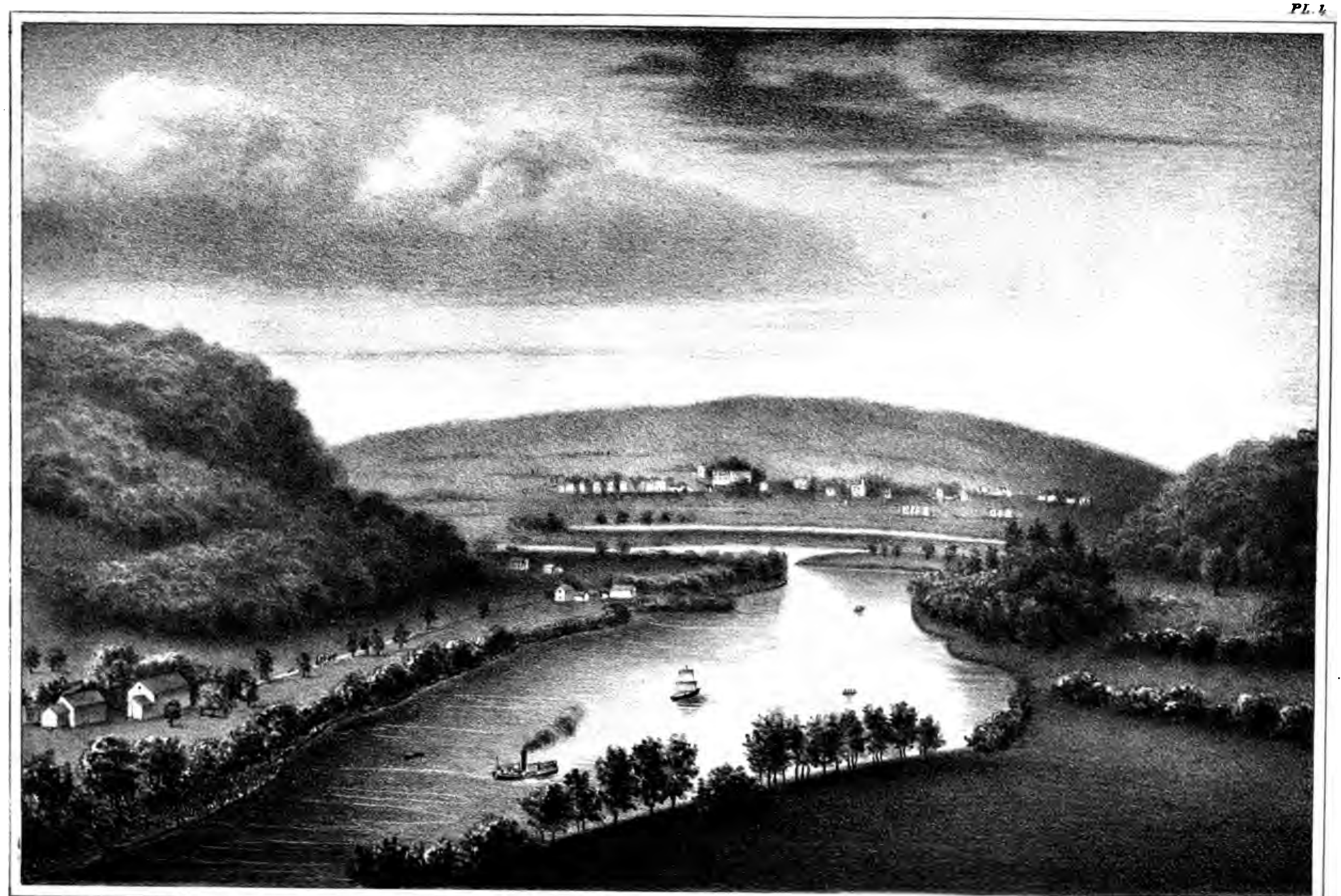
PL. 3.

Mrs Hitchcock del.

Thayer's Lith Boston

VIEW IN NORTH ADAMS.

PL. 4

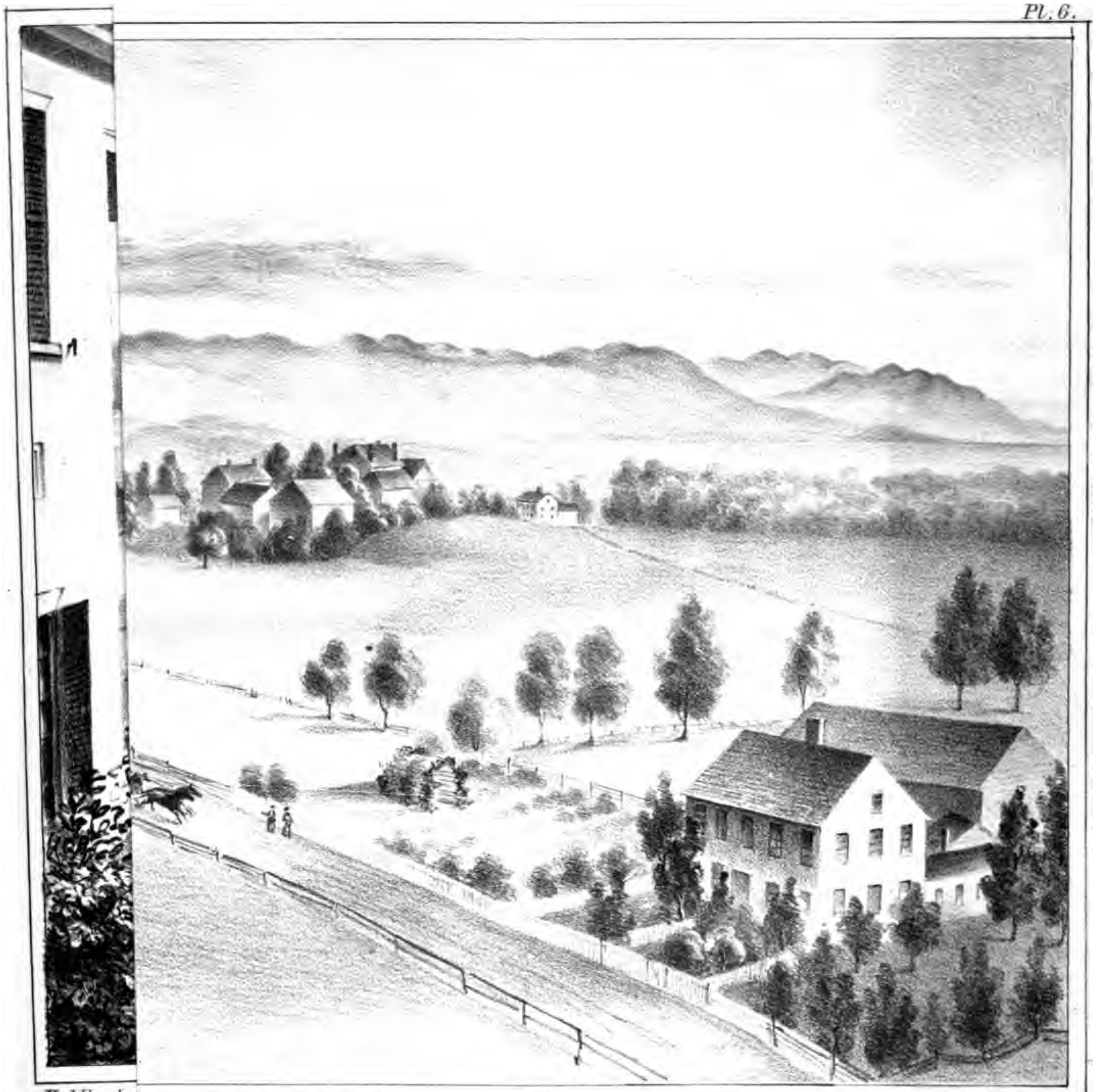


Mrs. Hitchcock del.

Thayer's Lith. Boston.

GORGE BETWEEN HOLYOKE AND TOM.

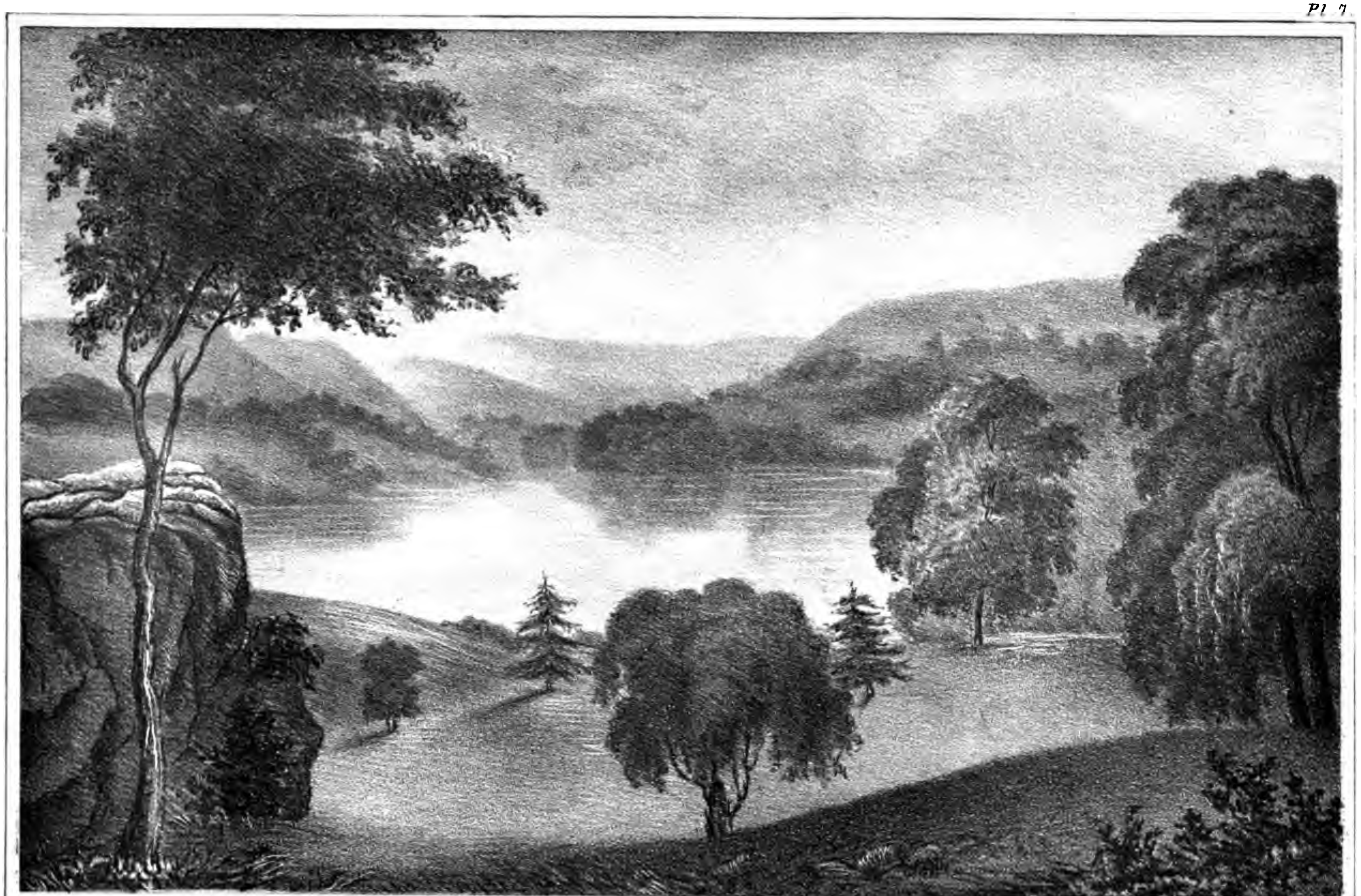
Pl. 6.



H. J. Van L.

Thayer's Lith. Boston.

Pl. 7.

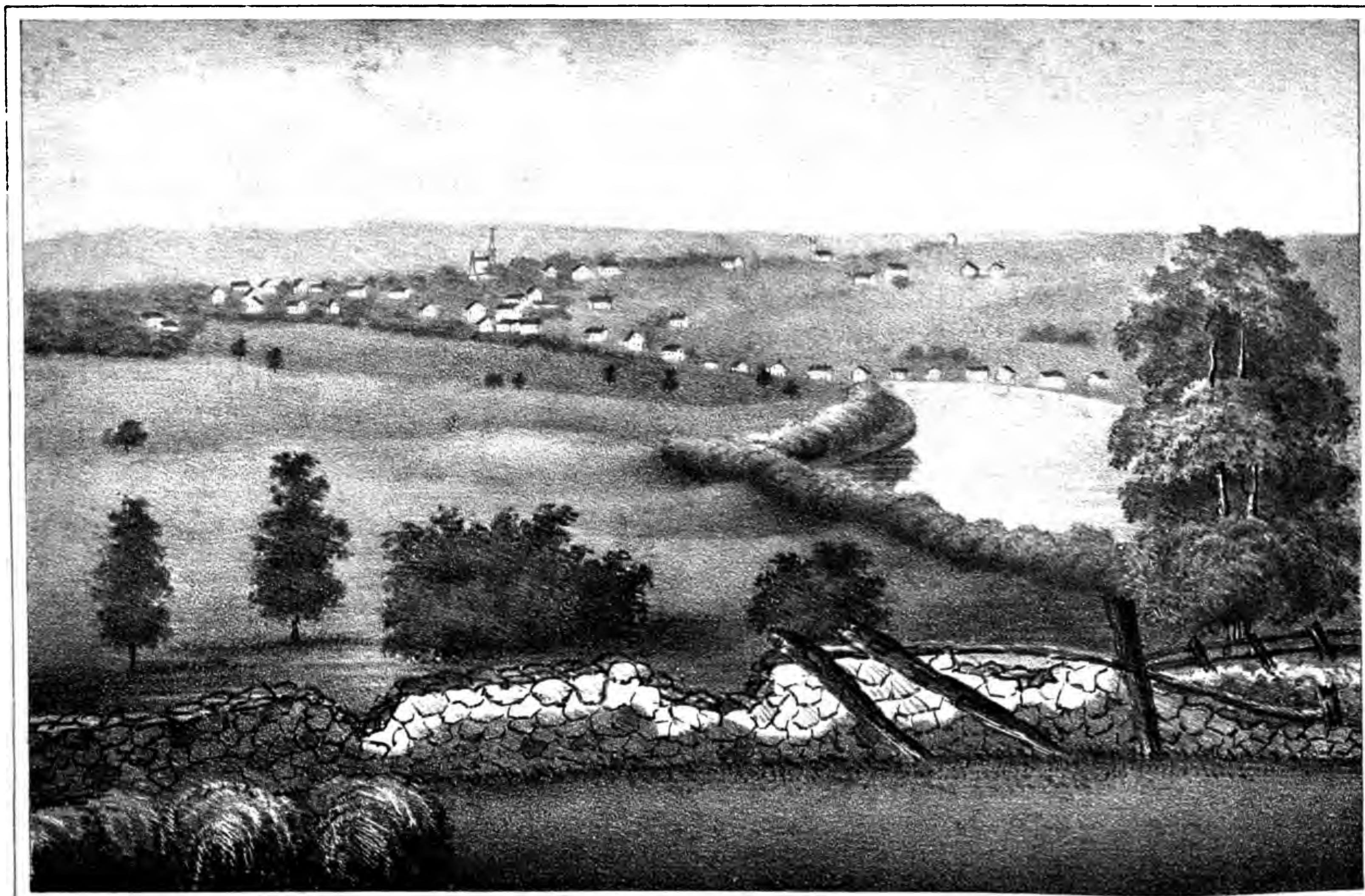


Miss M del.

Thayer's Lith. Boston

STOCKBRIDGE BOWL,

Pl 8

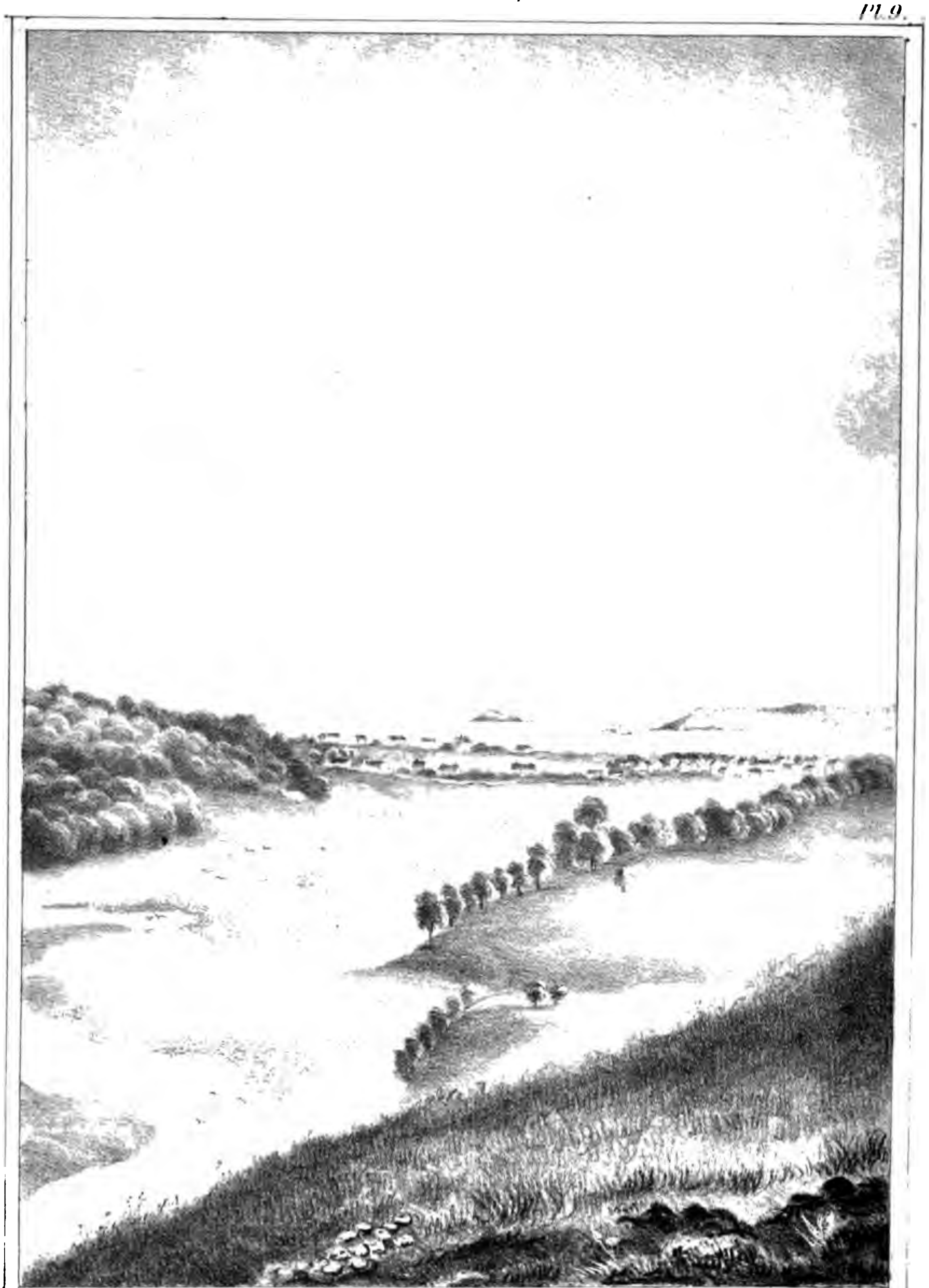


H. J. Van Lennep del.

Thayer's Lith. Boston

VIEW TOWARDS HAVERHILL.

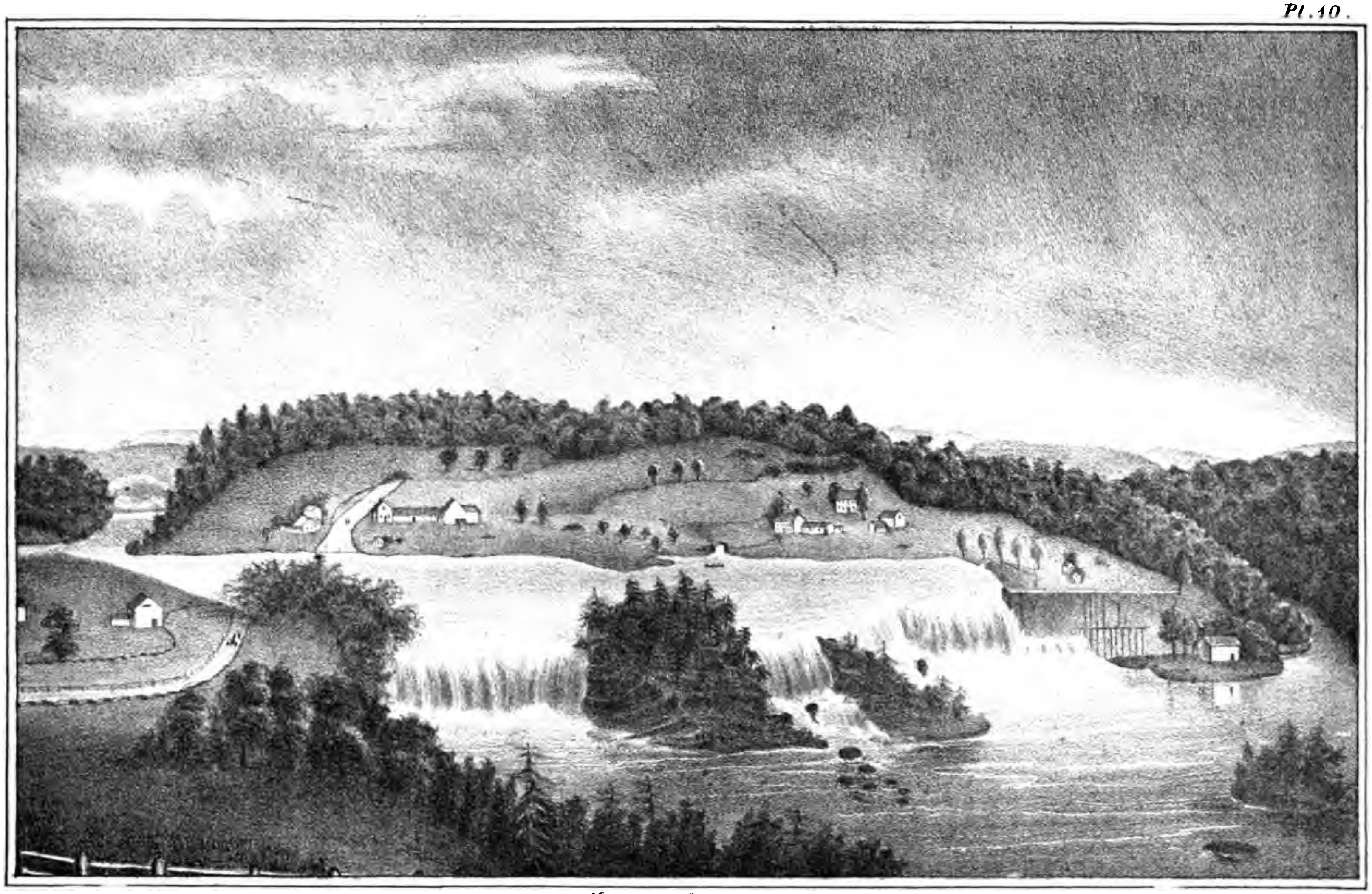
Pl. 9.



J. J. Van Lennep del. | Thayer's Lith. Boston.

VIEW FROM SAUGUS, TOWARDS LYNN.

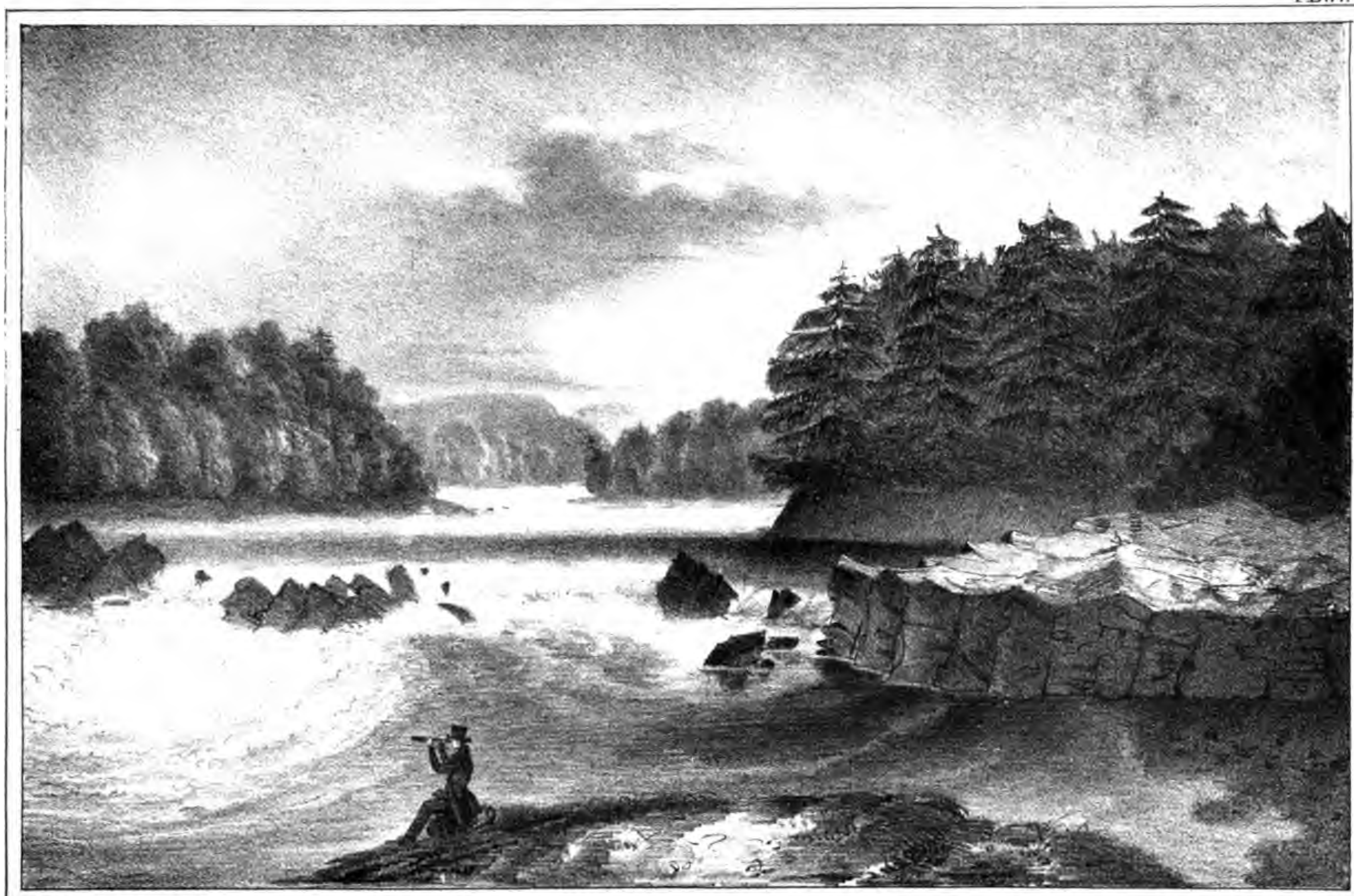
Pl. 10.



Mrs. Hitchcock del.

TURNER'S FALLS.

PL. 11.



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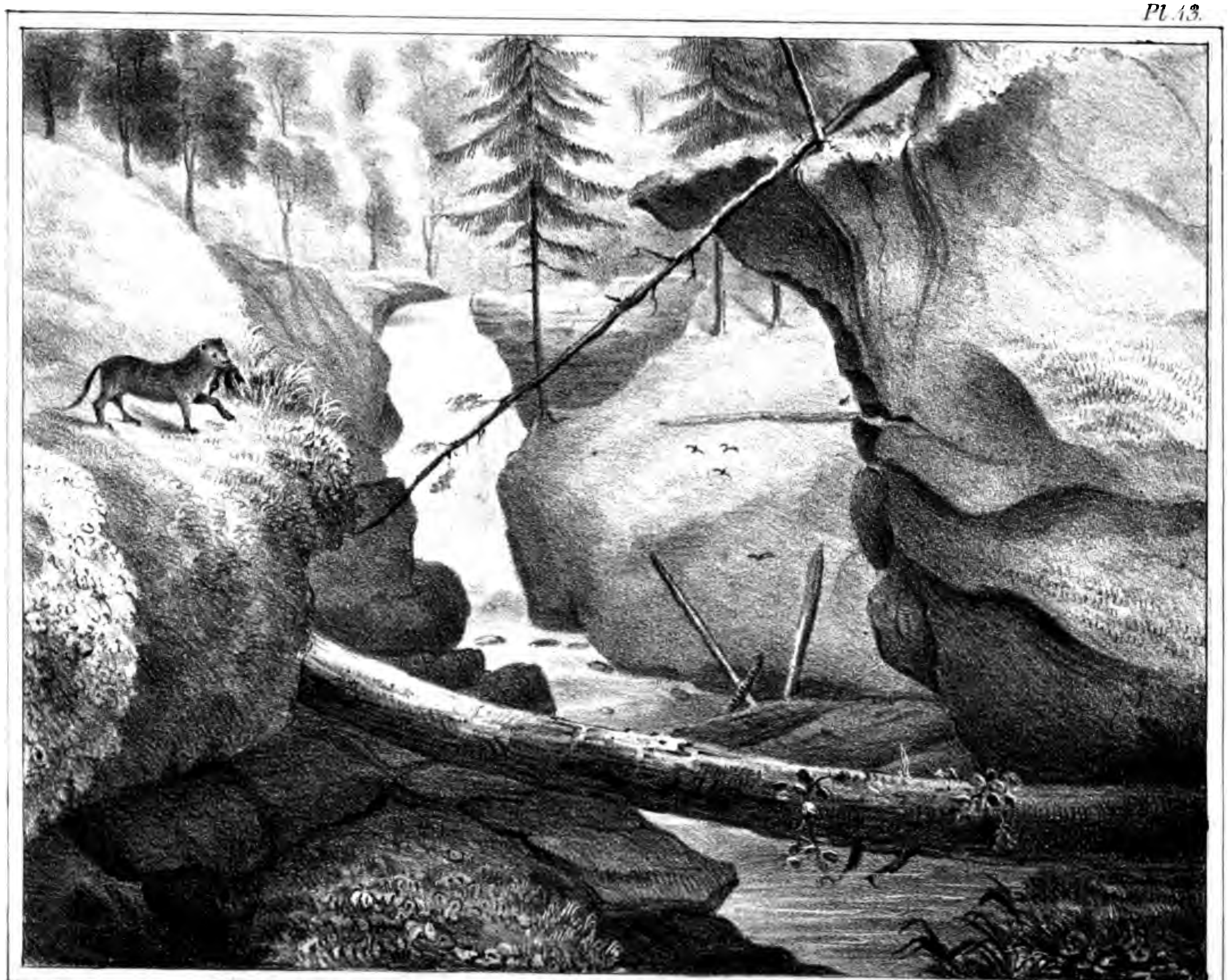
HOLYOKE'S FALLS IN MONTAGUE.

Pl. 13.



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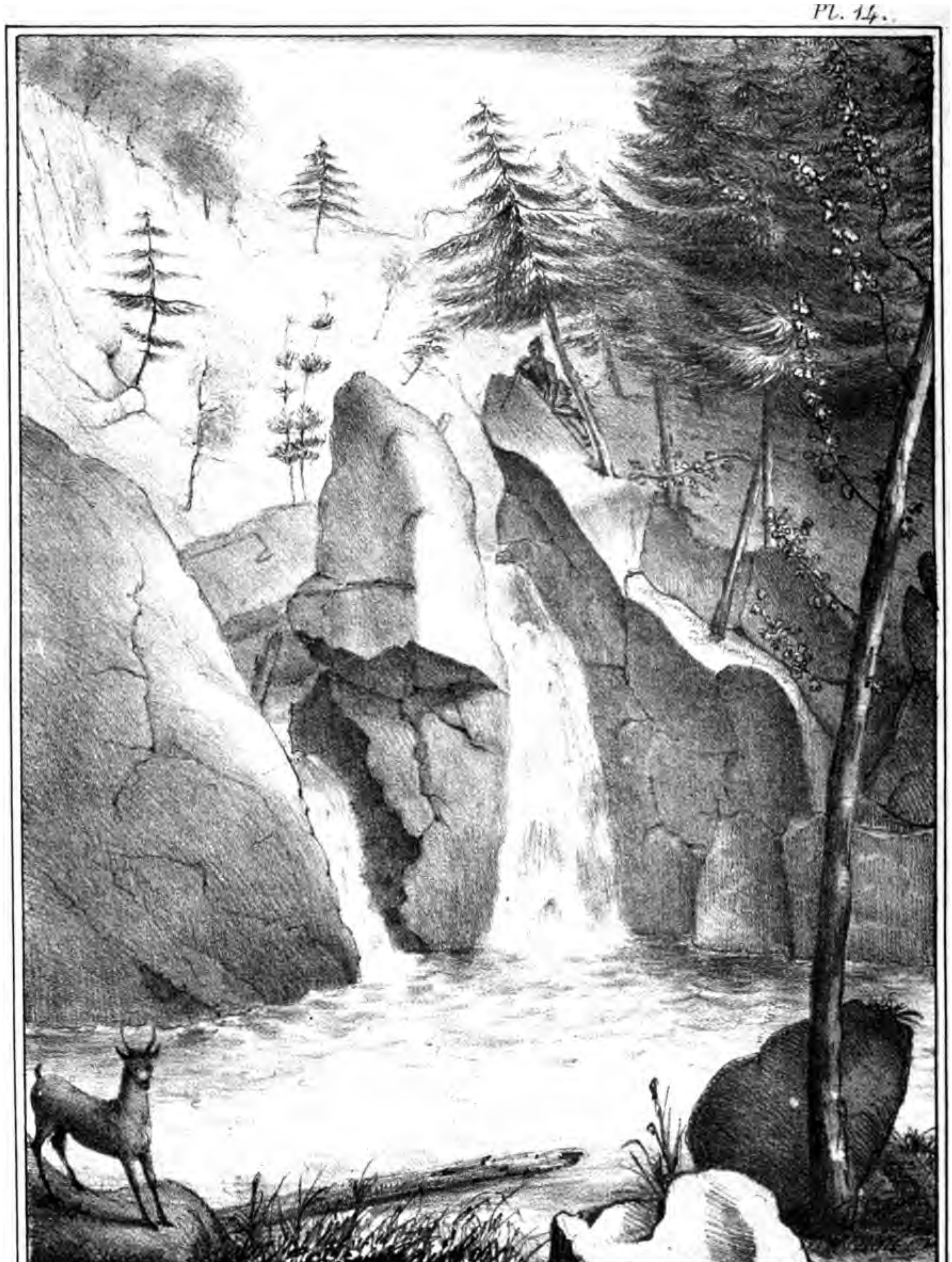
GORGE AND FALLS IN ROYALSTON, N.W. PART.

Pl. 14.



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BASHAPISH LOWER FALLS Mt WASHINGTON.